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RADIO and ELECTRONICS

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Contents Page

EDITORIAL 2

MINIATURE COMPONENTS FOR "PERSONAL PORTABLES" 4

HOME CRYSTAL PICK-UP INPUT CIRCUITS 7

A VACUUM-TUBE REGULATED POWER SUPPLY 11

QUESTIONS AND ANSWERS 15

MR. CORNEY INVESTIGATES 16

INDEX TO VOL. I OF "RADIO AND ELECTRONICS" 18

TUBE DATA: The HK54 Transmitting Triade 21

A NEW METHOD FOR PRODUCING RADIO SETS 22

THE RADEL DX BROADCAST 12, PART II 26

METHODS OF MEASURING SMALL VOLTAGE —PART II. By the Engineering Division, Aerovox Corp. 29

THE SERVICE SECTION:
Practical Trouble Shooting—Part IV. By C. R. Leslie 33

A PRACTICAL BEGINNERS' COURSE—PART 10 37

FOR THE SERVICEMAN:
Columbus Model 65 40

MAKING WORK A PLEASURE 41

OUR GOSSIP COLUMN 43

CLASSIFIED ADVERTISEMENTS 48

TRADE NEWS 47

OUR COVER this month shows one of the most recent British post-war radio receivers. It is remarkable for having no cabinet, the speaker and "works" both being mounted at the back of a flat baffle.

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●

BUSINESS ADDRESS:
46 Mercer Street, Wellington.

TELEPHONE:
Wellington 44-919.

Distributors for Australia:
NEW SOUTH WALES BOOKSTALL PTY. LTD., Market and Castlereagh Streets, Sydney.

Published for the proprietors by FEATURE PRODUCTIONS, P.O. Box 5065, Wellington.

Printed by Harry H. Tombs Limited, 22 Wingfield Street, Wellington.

THE 100-WATT MAXIMUM

In amateur transmitting circles there has always been much divergence of opinion on the subject of power output, but it is safe to say that a large proportion of amateurs in this country work right up to (and sometimes, be it whispered, beyond) the official maximum of 100 watts D.C. input to the final amplifier. If we add to this the fact that many of those who do not use 100 watts input are deterred only by the expense of the required equipment, it seems that there is a large body of opinion which is in favour of using as much input power as possible.

Although, broadly speaking, a powerful transmitter will lay down at a distant point a greater signal than will a small one (which is presumably the principle upon which the high power exponents base their preference) there is a great deal of misconception about this point, particularly in regard to its degree of truth under amateur conditions.

Suppose we are in possession of an efficient transmitter and aerial system, with which we use 25 watts input to the final amplifier. How much would we stand to gain if we built, at considerable expense, a rig which used 100 watts input? At first sight, the answer would appear to be "quite a lot," because, after all, we now have four times the power we had before. However, if we perform a simple calculation, we find that all that could possibly be gained would be a 6 db. better signal at the receiving end. A gain of this magnitude is certainly appreciable, but it is doubtful whether such a change would allow a great enough number of extra contacts to be made to render it worth the money. Less than 6 db. gain to bring the final input up to the 100-watt mark can definitely be characterised as uneconomic. For example, anyone who has a good, efficient 50 watts would be very ill advised to scrap it for a 100-watt transmitter.

The above argument is not the only one that can be advanced in favour of low-powered transmitters. Since the advent of the ZC1 to the amateur bands, it has become abundantly clear that, in spite of the crowded state of the bands, a mere one-and-a-bit watts can give excellent results, not only for local, but also for DX contacts. Not that everyone would be doing well to limit themselves to such a small power, for that is not the point. What is more important, though, is that a low-power transmitter with an efficient aerial system is frequently far better in terms of results than a high powered one with an indifferent aerial—a combination far too often found.

One of the reasons for this is that there is a natural tendency to rate transmitter power more highly than an efficient aerial. Another is that amateur literature is somewhat deficient in aerial data, particularly that part of the subject which deals with the theory of their operation, and with the "whys" as well as the "hows" of antenna adjustment. A further contributory cause is that many amateurs have not the space in which to erect a half-wave radiator on the 80m. band. This need not result in an inefficient aerial, but frequently does, because of a dearth of information on how to load shortened antennas. Such information does exist, however, so that no one, if he is sufficiently exercised about it, need put up with an inefficient aerial just because it has to be short.

The fact is that a good transmitting aerial is the *first* necessity and all thought of high-powered transmitters should be put aside until one's aerial is known to work properly. If this is the case, then an inexpensive low-powered transmitter will give all that most amateurs require in the way of results, and at the same time will cause a minimum of QRM, for a badly operated high powered job is much more likely to clutter up the higher frequency bands with harmonics—and frequently does so. There is a good deal more which could be written on this subject did space allow, but this is a beginning, and it is high time that someone sang the virtues of QRP.

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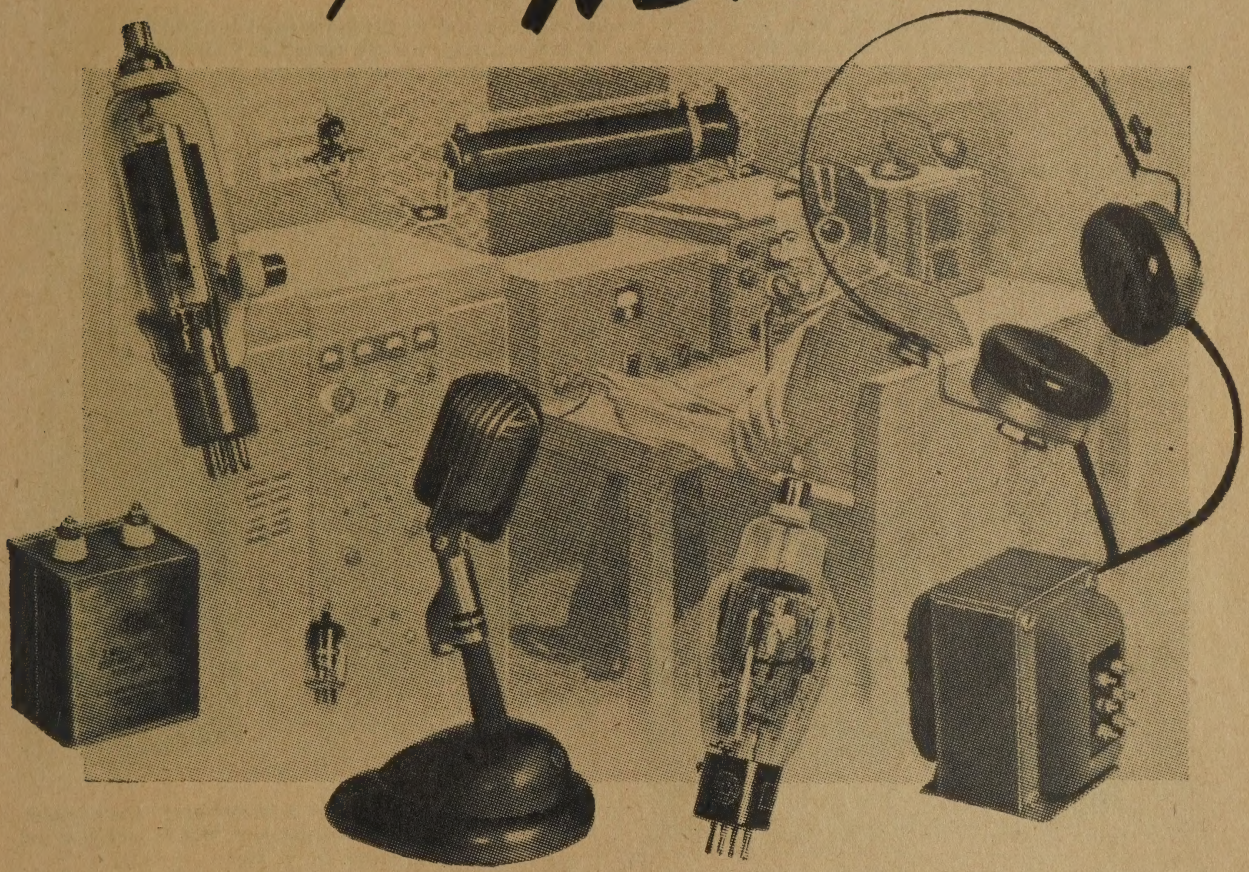

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MINIATURE COMPONENTS FOR "PERSONAL PORTABLES"

By H. W. BARNARD.

As a result of research, both in Britain's radio industry and in Government laboratories, into the problem of reducing the dimensions of components, manufacturers and amateurs now have an entirely new field of construction open to them.

One of the biggest manufacturing problems with which Britain's radio industry was faced during World War II was that of reducing the size of essential components to a fraction of their standard dimensions.

There had been little or no demand in Britain for "personal" portables, and manufacturers had not, therefore, gone into the question of miniaturisation. When, however, the Supply Ministries requested the industry to produce miniature components, light equipment to be used by forward troops, and for such apparatus as combined transmitter-receivers small enough to be worn on the belt by agents and members of resistance groups in enemy-occupied territory, research workers in Britain's radio industry set about getting the proverbial quart into a pint bottle.

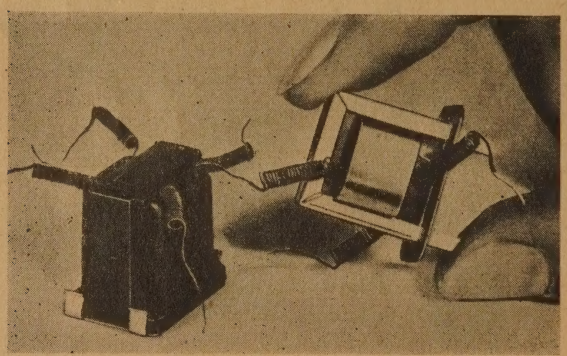

Fig. 1.—Midget audio-frequency transformers, available in "skeleton" form or with a bakelite case.

It was essential in 1940, when France and the Low Countries were overrun by the Nazi oppressor, that some form of radio communication should be established between the "intelligence" branch of the British Army in England and the resistance movement on the Continent. Miniature sets for this purpose, housed in slender curved cases to fit the line of the body, to be worn on a belt around the waist, were dropped by parachute in hundreds to men and women on the Continent.

PROXIMITY FUSE

Another major problem for manufacturers came when the proximity fuse, mounted in the nose of an anti-aircraft shell, began to be developed. This necessitated not only the reduction in size of all the components, but at the same time ensuring that they would withstand the tremendous shock on being fired.

Although in general the war-time development of fixed capacitors took the line of improving temperature and humidity-resistant characteristics rather than that of drastically reducing their size, the exception was the miniature capacitor developed for inclusion in the proximity fuse. This tubular paper capacitor, of which millions were produced, is rated for a D.C. working voltage of 500. The overall length for capacitances of from 0.0005-0.01 mfd. is $\frac{3}{4}$ in., ex-

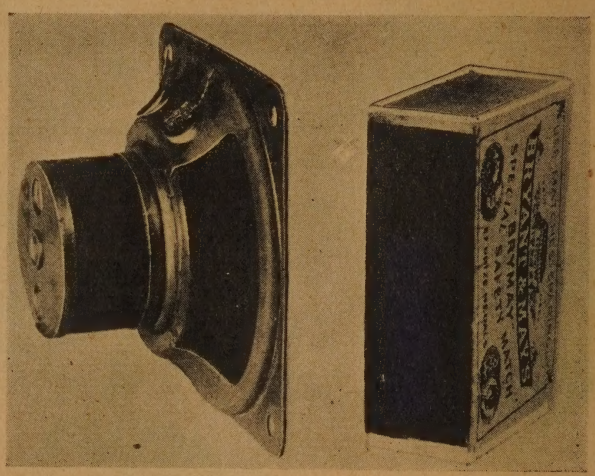

Fig. 2.—Little bigger than a matchbox. Permanent-magnet moving-coil loudspeaker which handles an input of $\frac{1}{2}$ watt.

cluding connecting wires, while the diameter varies from three-sixteenths of an inch to eleven-thirty-seconds of an inch. The units, wound and connected to provide minimum inductance, are dried and impregnated under vacuum in petroleum jelly and then immersed in high-melting-point wax.

What is probably the smallest plain foil electrolytic capacitor in the world has been produced by one of Britain's manufacturers. This has been made possible by the introduction of a new method of mounting the small negative electrode within a thin metal case and then closing the ends of the case on to synthetic rubber end-plugs, through which the connecting tags pass. These capacitors, the body dimensions of which are one and nine-sixteenths of an inch by eleven-thirty-seconds of an inch, open up entirely new uses for electrolytics. They have exceptionally good temperature characteristics. For example, at 50 deg. C., the capacitance is still approximately 50 per cent. of its value at 15 deg. C. The maximum working temperature is 71 deg. C. There are six values available, the smallest being 1 mfd. and the largest 20 mfd., their

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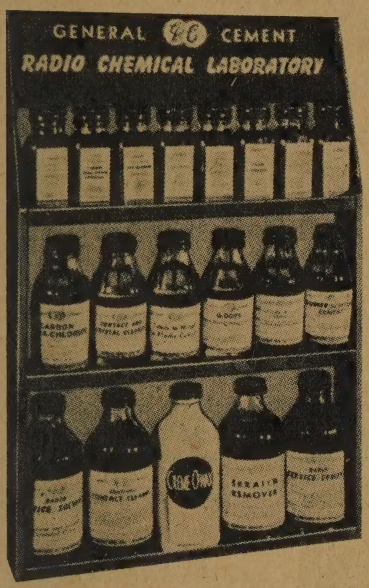

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maximum peak working voltages being 350 and 12 respectively. Paper capacitors in aluminium tubes with synthetic rubber end-plugs varying in diameter from one-fifth of an inch to three-eighths of an inch and in capacity from 0.001 mfd. to 0.1 mfd. have been produced with an overall length of from 1 in. to 1½ in.

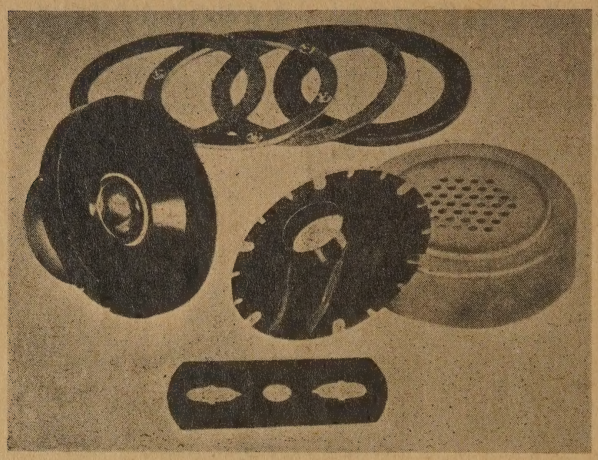


Fig. 3.—Component parts of a moving-coil earpiece compared with a safety razor blade.

A manufacturer of audio-frequency chokes and transformers has produced "thumbnail" components for war purposes and these are now available for domestic receivers. Despite their small size, these transformers and chokes, which measure one and three-sixty-fourths of an inch long, nineteen-thirty-seconds of an inch deep, and thirteen-sixteenths of an inch high, have a very uniform response throughout the range of speech frequencies needed for communication.

A series of I.F. transformers, designed for maximum gain and selectivity, yet occupying a minimum of space, was manufactured during the war for inclusion in walkie-talkie sets and miniature receivers for beach-landing parties and are now available for general use. The coils are contained in enclosed pot-type iron-dust cores with adjustable iron-dust centre cores. Trimming capacitors are mounted inside the screening can, which measures one and thirteen-sixteenths of an inch deep and thirteen-sixteenths of an inch square. Tested between a 6K7 valve and a standard valve voltmeter, these transformers have a gain of 60 at a frequency of 1 mc/s.; at 2.1 mc/s. the gain is 28, and at 4.86 mc/s. it is 15.

The most outstanding reduction in size is probably that of the midget permanent-magnet moving-coil loudspeaker. One type has an overall diameter of only 2½ in. and occupies a depth of but one and thirteen-sixteenths of an inch. This miniature speaker, the voice coil of which is half an inch in diameter, is capable of handling inputs of up to half a watt.

Although externally it is no smaller than normal headphones, a moving-coil earphone, designed by one of Britain's leading loudspeaker manufacturers for large-scale production, warrants a place in this survey of miniaturisations in that its construction necessitates the production of a miniature moving coil and cone diaphragm. Improvements in permanent magnet alloys have contributed largely to the reduction in size. The permanent magnet is less than an inch in diameter. The moving coil is only half an inch in diameter and consists of four layers of 46 S.W.G. in a 0.032-inch gap.

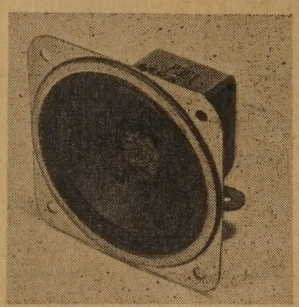
Although some millions of these units were produced in Britain by the designers, the output was not adequate to meet the tremendous demands from all the fighting services. A prototype, therefore, was sent to the U.S.A., Canada, and South Africa, where further millions were manufactured to the original specification.

MULTI-CONTACT SWITCH

In response to a request from Britain's Ministry of Supply for a really miniature multi-contact switch, capable of withstanding the conditions in the Far Eastern war zone, one engineering company produced a rotary wave-change switch with all moving parts and contacts hermetically enclosed, and yet its overall dimensions, including soldering tags, are ¾ in. in diameter and thirteen-sixteenths of an inch deep (behind the panel). One of the biggest problems in producing this switch was that of silver-plating the very small contacts. This had to be of extra fine finish to allow the relatively small contact area to

(Concluded on page 46)

TWO SPECIALS — while they last



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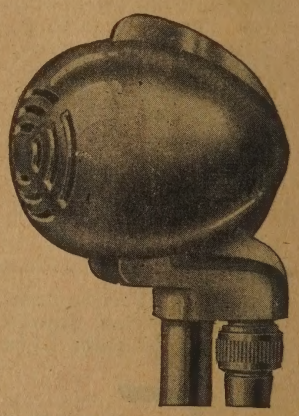

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SOME CRYSTAL PICK-UP INPUT CIRCUITS

It is sometimes forgotten that crystal pick-ups, although superior in many respects to low-priced magnetic ones, themselves suffer from certain defects which can, to an extent, be remedied by the use of simple resistance-capacity networks between the pick-up itself and the amplifier into which it is to work. This article presents a few circuits which can be used in this connection.

Before proceeding to describe actual input circuits which can be used with crystal pick-ups, it will be useful to say a few words about the pick-ups themselves.

When crystal pick-ups were first introduced commercially, they were hailed by many as the final answer to the problem of providing reasonably good record reproduction in the home at a cost which was not prohibitive. To a limted extent this turned out to be the case, but as with many new ideas whose charm is partly in their novelty, some of the inherent limitations of these instruments tended to become forgotten, while others were not brought to light until long after their initial burst of popularity. In spite of the large sales of crystal pick-ups for home use, they have not become general, or even very widely used in broadcasting studios for the reproduction of ordinary shellac commercial records. In the broadcasting field, the very expensive high quality moving iron pick-up still holds the field, which would indicate that crystal pick-ups still leave something to be desired.

It is no part of our purpose here to decry the quality or usefulness of the average crystal pick-up, but to help users to obtain from it the best possible results. In order to do this, it is necessary to detail some of the known defects and see how they may be overcome, wholly or in part.

EQUIVALENT CIRCUIT

The equivalent circuit of a crystal pick-up is shown in Fig. 1. Rl is the load resistor, and the pick-up itself is represented by a generator in series with a capacity C. From this, it can be seen that the pick-up consists essentially of a generator of zero or low internal impedance, in series with a capacity which in practice is that of the crystal and its electrodes, regarded simply as a parallel plate condenser. The size of the capacity will vary with individual makes of pick-up, but is in the region of 0.02 mfd.

In order to operate the pick-up into the grid of an amplifier valve, it is necessary to place a high-resistance Rl in series with it, and to take the ungrounded terminal of the combination to the grid of the valve. The equivalent circuit of Fig. 1 gives us a good clue to the effects which are likely to occur when the value of Rl is altered. C and Rl in Fig. 1 can be regarded in exactly the same way as the coupling circuit between two valves in which Rl is the grid leak and C is the coupling condenser. The manner in which the frequency response of this simple network reacts to different values of C and R is well known, and was, in fact, the subject of a design sheet No. 4 in our series, published in the last issue of "Radio and Electronics." Briefly, the constants of the network affect only the low-frequency response (unless the values are impossibly small) and the important quantity is the product of C and R. Thus, in general, any desired low-frequency response can be achieved with a particular value of C and R, simply by choosing the right value of the other component. In this case, C is fixed, because it is determined by the construction of the pick-up. It is clear, therefore, that the desired low-frequency response can be obtained (in theory, anyway) simply by choosing the right value of Rl. The rule is that the higher the value of R, the better will be the response at low frequencies.

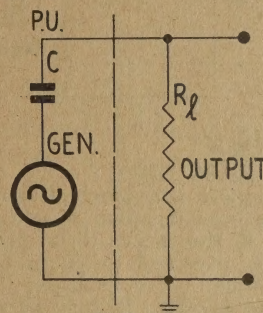

FIG. 1

Equivalent circuit of any crystal pick-up, together with its load resistor.

TYPE OF OPERATION

The simple state of affairs outlined above cannot be regarded as the whole story, unfortunately. In an earlier article ("Radio and Electronics," March, 1947), reference was made to constant velocity and constant amplitude recording, and to the fact that the moving-coil type of pick-up is a constant velocity device. However, with crystal pick-ups, complications ensue, because they are neither pure velocity operated nor pure amplitude operated instruments, but a rather indeterminate mixture of both, in most cases.

Most crystal pick-ups approach more closely to constant amplitude operation than to constant velocity. This means that, if they are used with a constant amplitude type of recording, the frequency response of the combination would be almost straight and level. But, commercial discs being what they are, viz., a mixture of constant amplitude at low frequencies and constant velocity at medium and high frequencies, the process of increasing the low-frequency response of the pick-up by increasing the load resistor Rl tends to have the simultaneous effect of dropping the response at middle and high frequencies.

Thus, although it is a simple matter to increase the low-frequency response of the pick-up, it is necessary at the same time with most instruments to ensure that so doing does not affect adversely the high-frequency response.

PRACTICAL CIRCUITS

It is with the above ideas in mind that the accompanying circuits have been presented. They are samples of one possible kind of circuit only, and do not pretend to exhaust the possibilities or even to cover them partially. For example, corresponding parallel networks could be used with very similar results, but to include these would not make much

practical difference. Also, no mention is made of arrangements using tuned circuits. Although some of the latter may be successfully used, they are more difficult to construct, since they require high-quality iron-cored chokes of unusual values of inductance. These chokes are difficult to obtain and expensive to have made, and at the same time introduce hum-pick-up troubles owing to the fact that the full amplifier gain comes after the pick-up circuit.

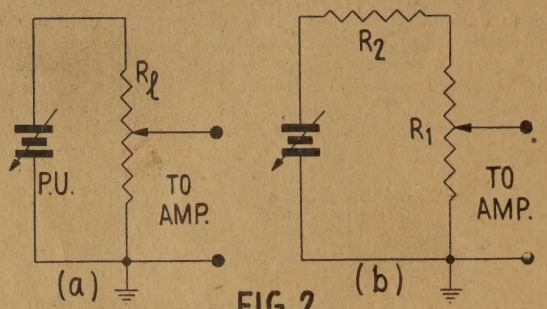

FIG. 2

SIMPLE BASS LIFT

Fig. 2 shows the simplest and most elementary circuit for improving the bass response of a crystal pick-up. In Fig. 2 (a), all that needs to be done is to increase the value of R1 over and above the figure recommended for normal use. For example, if the recommended load resistor is 500k., R1 may be made a 1 meg. or even a 2 meg. potentiometer, acting both as load resistor and volume control. In all these diagrams the "high" output terminal should go directly to the grid of the first amplifier stage, and should not have a condenser in series with it.

In many cases R1 is the built-in volume control at the input of the amplifiers, and increasing its value means replacing an existing component. However, if it is not desired to do this, the circuit of Fig. 2 (b) may be used. Here, the existing volume control potentiometer R_1 is retained, and extra resistance R_2 is inserted in series with it and the pick-up output lead. For instance, if R_1 is a 500k. potentiometer, and it is desired to bring the pick-up load resistance up to two megohms, R_2 would be 1.5 megohms.

A point with this circuit is that the maximum available output voltage is reduced to a quarter of that obtainable with the circuit of Fig. 2 (a). However, this is seldom a disadvantage, as the amplifier usually has plenty of gain to spare, and as long as the output voltage now available is sufficient to drive the amplifier to full output, no disadvantage exists.

Should the output be insufficient, however, the same amount of compensation can be effected, but more output voltage is made available, by making R_1 a 1 meg. potentiometer and making R_2 a 500k. resistor. The important point to notice is that so long as R_1+R_2 always has the same value, the frequency response will remain constant. It is also good practice to limit R_1 to 1 meg., because this is the maximum allowable D.C. grid resistance for most valves used as voltage amplifiers.

It should be emphasised that the total load of 2 megohms, as used here, is purely an illustration, and not necessarily a value that will be right with any particular pick-up. Exactly how much resistance is required to give the desired frequency response is a matter for individual testing, preferably by ear, until the best results are obtained with the equipment used.

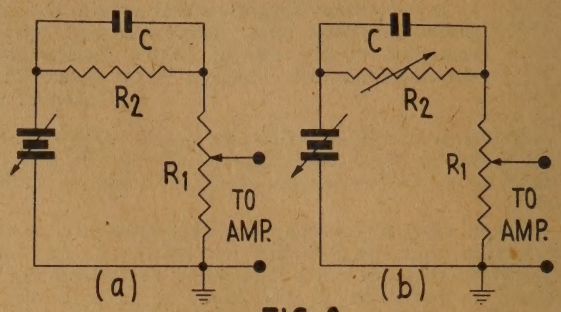

FIG. 3

IMPROVEMENT OF HIGH-FREQUENCY RESPONSE

It will be found that the simple scheme of Fig. 2 has one major drawback. That is, it is not possible to carry the bass boosting very far by this means before the higher frequencies have the appearance of being strongly attenuated, and the reproduction sounds "wooffy." If the value of load resistance is increased only to the point where the high frequencies start to drop off noticeably, it is usually found that there is still not enough low-frequency response. However, Fig. 3 gives us a way out of the difficulty. Fig. 3 (a) is the same circuit as Fig. 2 (b) with the addition of the condenser C, which has a value usually between 50 mmfd. and 250 mmfd. Its action is readily seen when it is remembered that the reactance of a given condenser decreases with increase in frequency. Thus, at low frequencies, the reactance of C is very high indeed—so high, in fact, that C can be regarded as absent, so that the low-frequency circuit is for all practical purposes exactly that of Fig. 2 (b). However, as the frequency increases, so the reactance of C decreases, and R_2 becomes partially bypassed for medium frequencies, and completely so for high audio frequencies. The circuit of Fig. 3 (a) therefore gives a bass boosting effect, due to the high load resistance, and at the same time a high frequency boost, owing to the fact that C passes on the high frequencies from the pick-up without attenuation. Here, again, no specific values are given, but a suggested starting-point for experimentation is to make R_1 a 500k. pot., R_2 a 1 meg. fixed, and C_1 100 mmfd.

It should be noted in connection with Fig. 3 (a) that altering the ratio of R_1 and R_2, while keeping their sum constant, will now produce quite a different effect. The reason is that the high frequency lift provided by C will depend to some extent upon the size of R_2. For instance, the larger R_2, the smaller C needs to be to give a fixed amount of top lift.

Fig. 3 (b) is a variation of Fig. 3 (a), in which R_2 has been made variable. This circuit is really much more versatile than Fig. 3 (a), since it can be used to vary both bass and treble boost simultaneously. For example, where C is short-circuited, we have the circuit of Fig. 2 (a), while if R_2 has a high value we have the circuit of Fig. 3 (a). With intermediate values of R_2 the results will also be intermediate between those obtained with the fixed cir-

cuits of Figs. 2 (a) and 3 (a) respectively.

If a variable equaliser is not required, Fig. 3 (b) can be connected up and used to experiment with various values of C and R_2 until the most pleasing combination is found. R_2 is then measured, and a fixed resistor substituted, of the value indicated.

FURTHER VARIATIONS

Since Fig 3 (b) varies both high and low-frequency boost at once, and this characteristic may not be desirable, it is useful to have a circuit in which the bass lift is fixed, but which gives control of the high-frequency response. Such a circuit is given in Fig. 4 (a). Here R_2 has been fixed to give the desired bass boost, and the size of C is arranged after

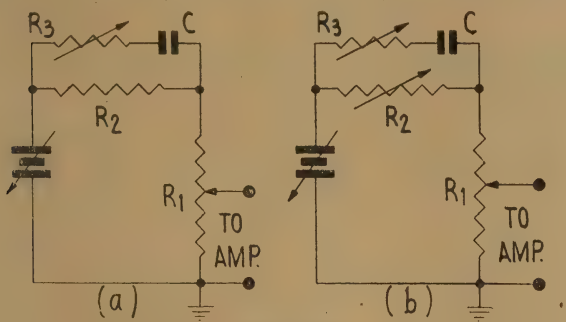

FIG.4

this to give the maximum required top lift when R_3 is short-circuited. In this condition the circuit is simply that of Fig. 3 (a). If R_3 is open-circuited, the circuit reduces to that of Fig. 2 (b), so that if R_3 is made high in value compared with R_2, the variation in R_3 can be made to give any response intermediate between those of Figs. 2 (b) and 3 (a), while leaving the low response unaffected.

Fig. 4 (b) shows yet another variant, in which R_2 also is variable. This circuit gives almost independent control of low and high-frequency response.

VALUES TO BE USED

As stated above, no attempt has been made here to lay down any particular values that should be used, since these will depend both on the pick-up and on individual listening tests. However, experimentation might well start with the following values in Figs. 2, 3, and 4. R_1=½ meg. pot., R_2 and R_3=2 meg. pots., and C=100 mmfd.

With a circuit of this kind it is very easy to "play" for hours and reach no conclusive result, especially since listening tests are so difficult to carry out. However, if one value at a time is changed in the case where fixed components only are used, there should not be much difficulty in deciding on its best value. For example, suppose it is desired to make Fig. 3 (b) the final set-up. R_1 can be fixed at 0.5 megs., C can be fixed, and R_2 varied until the best results are obtained. If R_2 is found to give too great a variation, the effect can be tried of reducing the amount of variation by making R_2 a 1 meg. pot. in series with a 1 meg. fixed resistor. This trick can be resorted to to limit the range of control of any of the variables shown.

If tests are made in a logical order, one at a time, and if at the same time the remarks here about the method of action of the various components are remembered, it should be possible for a constructor to build a fixed or variable pick-up equaliser that will suit his own requirements almost exactly.

Since crystal pick-ups are high-impedance devices, their output leads are always run in shielded wire to prevent hum pick-up. It is not generally realised, however, that this shield lead may be run for quite long distances without affecting the frequency response. All that will happen if this is done is that the overall level will be reduced a little. The reason for this exceptional behaviour is found in the fact that the pick-up itself is a capacitative device, so that adding capacity in parallel with it has little effect on the frequency response, since it really acts in series with the capacity of the crystal unit, the two capacities forming a capacitative voltage divider, whose frequency response remains almost unaffected as long as the load resistor is high in value.

To minimise hum pick-up, the circuits shown should all be constructed with as short leads as possible, and preferably completely shielded in a small iron box. The leads from the equaliser to the grid of the first amplifier tube should be as short as possible—not more than an inch or two—to prevent high-frequency loss and further hum pick-up.

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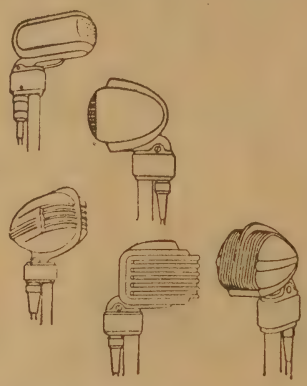

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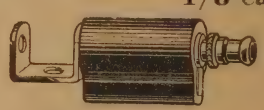

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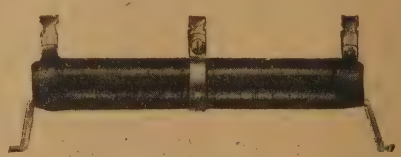

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A Vacuum Tube Regulated Power Supply

Very few amateurs and experimenters have not felt the need at one time or another for high-voltage power supply with regulation comparable with that of batteries yet without their expense and inconvenience. While the circuit given here is not a new one, practical details are given which will enable a constructor to build a supply giving from 200 to 500 volts with any required current capacity.

CIRCUIT

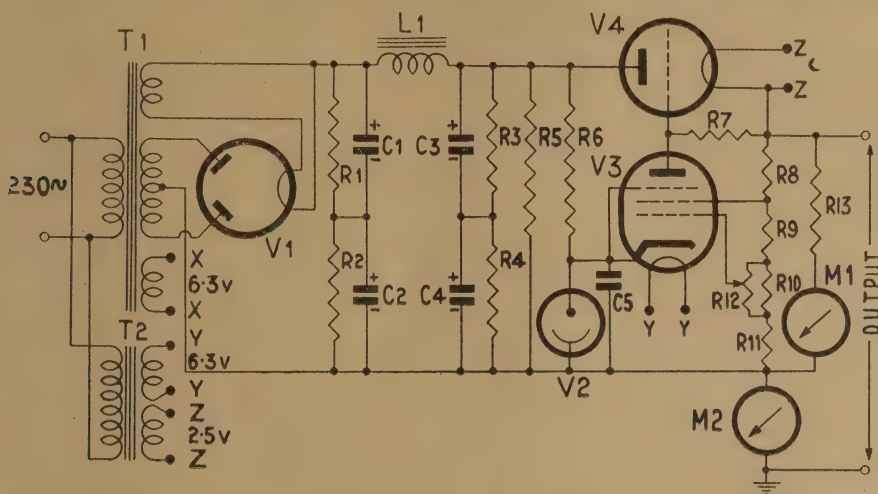
The circuit will be recognised as an old friend which has been about in the literature for some years now. Most similar designs have suffered from the disadvantage that they relied for their success either on a small dry battery, for biasing the amplifier tube, or on a small neon lamp, of somewhat indeterminate characteristics, and difficult to obtain.

However, now that VR tubes are commonplace, both these disadvantages are overcome, and the excellent performance of this type of power supply may be obtained by anyone at quite reasonable cost. For the benefit of those who may not have met this circuit before, a few words of explanation may be an advantage.

First of all, the power supply up to and including R_5 is quite standard in design, and uses a full wave rectifier V_1, followed by a condenser-input filter. In the model constructed in our laboratory, we required a regulated voltage up to as near 500 volts as we could get, so that a 450-volt-a-side transformer was used. This accounts for the series condensers in the filter circuit and their associated balancing resistors, R_1 to R_4 inclusive. We will have more to say later on the subject of voltage and current requirements.

In brief, the principle of operation of the power supply is that V_4 is placed in series with the high voltage lead, and acts as an automatically variable resistor which keeps the voltage at its filament constant, irrespective of changes in the input voltage or in the current drawn from the output terminals.

The automatic variation referred to is obtained by the use of V_2, which is a sharp cut-off pentode, and acts as a high-gain D.C. amplifier. The grid of V_4 is directly connected to the plate of V_2. The latter obtains its plate, screen, and grid potentials from the potential divider $R_8R_9R_{10}$ and R_{11}, which is connected to the output side of V_4. R_7 forms the plate load resistor for V_3. Now, since V_3 obtains both screen and grid voltage from the output side of V_4, any variations in voltage that occur at the output terminal will be applied (reduced in proportion) to the screen and grid of V_3. These variations in voltage will be amplified by V_3, and will result in amplified variations, but opposite in polarity, at the plate of this tube. For example, should the load on the power supply draw more current, the output voltage will tend to drop. This drop causes the grid voltage of V_3 to drop slightly, which in turn results in a decreased plate current in V_3. Thus, the voltage at the plate of V_3 increases slightly, making the grid of V_4 more positive with respect to its filament. This decreases the D.C. resistance of V_4, which causes an increase in the voltage at its filament. This increase compensates for the original drop at this point caused by the increased load current. Naturally, compensation cannot be absolutely complete, because **some** change must occur in the output voltage to cause any action in V_3 and V_4. The degree of compensation actually achieved depends on the gain realised between the grid and plate of V_3, and upon how nearly constant its cathode voltage is maintained.



T_1 = power transformer, 450-0-450v. 200 ma. 6.3v. 4 amp.; T_2 = filament transformer 6.3v. 1 amp., 2.5v. 10 amp.; V_1=5Z3 or 5U4-G; V_2=VR 75/30; V_3=6SJ7; V_4= four 2A3's in parallel (see text); R_1, R_2, R_3, R_4, R_7=1 meg. 1w.; R_5=25k. 25w. wire-wound; R_8= 50k. 5w.; R_9, R_{10}=10k. 1w.; R_9= R_{11}=5k. 1w.; R_{12}=100k. carb. pot.; R_{13}=500k. 1w.; C_1, C_2, C_3, C_4=16 mfd. 450v. electro.; C_5=0.1 mfd. 600v.; M_1=0-1 ma. moving coil; M_2=0-200 ma. moving coil; L_1=20H. 200ma. choke, 100 ohms D.C. res.

USE OF THE VR TUBE

If an ordinary cathode resistor were used for V_3, the regulating effect would be quite poor, since the alterations in plate current caused by variations in grid voltage would also bring about changes in cathode voltage, which would oppose the grid voltage changes, and thus decrease the effective amplification of V_3 towards the D.C. voltage at its grid. Another way of regarding the question is that V_3, being a D.C. amplifier, would be subject to negative feedback if a cathode resistor were used, because it would be

virtually impossible to bypass this resistor to D.C. changes of potential.

It becomes necessary on this score to provide a constant cathode voltage for V_3. One way of doing this would be to use a small battery of 22½ volts or more, but this is clearly undesirable if it can be avoided, more particularly since a considerably higher voltage than this is desirable. The older method of avoiding a battery was to use a small (1-watt) neon lamp, with its base resistor removed. This expedient, though workable, is not very desirable since the characteristics of neon tubes are somewhat variable, and there is more than a small likelihood of its going out. If this happens, the whole regulator ceases to function. In our circuit, a VR75/30 is used to stabilise the cathode voltage of V_2. This tube is specially constructed with regard to stability of operation, and can be relied upon so long as the current through it is within the working range of 5-30 ma. R_6, in series with V_2, ensures that whatever the current passed by V_3, V_2 always remains in operation. In any case, the current through V_3 alone would not be sufficient to maintain V_2 in the struck condition. A further advantage in the use of a VR75 is the fact that a high cathode voltage on V_3 is a help in obtaining the most effective regulation, and that an ordinary neon lamp, used in the same circuit, does not give as high a regulated voltage.

OUTPUT VOLTAGE CONTROL

Provision has been made for controlling at will the output voltage of the supply. This is the potentiometer R_{12}, which sets the average D.C. voltage at the grid of V_3 at any pre-determined value, and thus, by the same action as has already been described, sets the voltage obtained at the output terminals. Once R_{12} has been set to a given position, the circuit action will hold the output voltage at the predetermined value within a fraction of 1 per cent.

FILAMENT TRANSFORMER

Since the filament of V_4 and the heater of V_3 are at high positive voltages with respect to earth, separate filament windings are needed for these tubes, or alternatively, as shown here, a completely separate filament transformer. This leaves the 6.3v. winding on the main power transformer free for operating the heaters of any equipment that is to be run off the regulated power supply. T_2 should have sufficient insulation to withstand the full H.T. voltage of the supply between either secondary and core, and between the secondaries themselves. It need not be large, however, since all it has to supply in the case of a unit using four 2A3's in parallel as V_4, is 6.3v. at 0.3 amp. for the 6SJ7, and 2.5v. at 10 amps., making 27 watts in all.

H.T. TRANSFORMER

In the original model, where regulated voltage up to almost 500v. was required, a 450-volt-a-side transformer was used for T_1. However, if a lower maximum voltage is required, an ordinary 385-volt-a-side receiver transformer may be used. Also, in our case, a highly-rated choke with a low D.C. resistance (100 ohms) was used for L_1 so as to increase the maximum output voltage available. In addition, the bleeder R_5 was used as a safety device, to prevent the supply working with no load, should anything happen in the control circuit.

CHOICE OF TUBES

The 2A3 was chosen for V_4 because of its high mutual conductance and low D.C. plate resistance. The power supply cannot give any higher voltage than is produced at the input of the regulator portion, and must, in fact, give less than this.

With zero bias, a 2A3 gives a voltage drop between plate and filament of around 70 volts. Thus, the minmum drop through the four 2A3's, in parallel, which were used in the original would be 17½ volts. This is one reason for using the four tubes in parallel. The other reason is that a single 2A3 cannot be used to pass more than about 70 milliamps without overheating. Thus, four of them in parallel would give a total current capacity of 280 milliamps, which is more than sufficient to cope with the rated maximum of the power transformer. The question of the number of 2A3's used will be gone into in more detail later in this article.

The 6SJ7 was chosen for the position of V_2 because of its high gain capability and also because, being single-ended, it avoids the necessity of taking a grid lead through the chassis.

METERING

It is not necessary to connect meters in the circuit unless they are particularly desired, but if they are to be used, it should be noted that the 200 ma. meter which measures the output current is connected in the negative side of the supply. This prevents all possibility of damage to the circuit through breakdown in the meter insulation. In order to have the meter in this leg of the circuit, and at the same time to prevent the various bleed currents from reading on the meter, the negative side of the whole supply is insulated from the chassis, and is connected to it only through the meter. The output voltmeter consists of a 0-1 ma. movement with a 500k. resistor in series to give it a range of 0-500 volts.

MODIFICATIONS

The circuit as already described was built to fulfil the requirements of our own work, but many will no doubt feel that the voltage and carrying capacities provided by the prototype are a good deal larger than will satisfy their own needs. It is desirable, therefore, to indicate how the circuit given here may be modified to meet individual requirements.

In the first place, it should be pointed out that the important parts of the circuit are the potential divider from which screen and grid voltages for V_3 are derived, and R_6, the resistor which ensures that V_2 remains struck under all circumstances. **If the values of R_6 to R_{12} inclusive are strictly adhered to, individual choice can be exercised in the selection of the secondary voltage of T_1 and the number of 2A3's in parallel making up V_4.**

The first and most obvious modification that can be made is to use an H.T. transformer with a lower secondary voltage. This will result in lower output voltages, both at the minimum and maximum settings of R_{12}, as would be expected. The remainder of the circuit is not critical as to transformer voltage—certainly not down to the usual figure of 385-volt-a-side, so that a standard receiver transformer may be used with complete success. With the circuit constants shown, however, it would not be advisable to

reduce the transformer voltage below this figure.

The other simplification that can be made is to reduce the number of 2A3's used in parallel for V_4. Doing this simply drops the available output voltage at high current drains, or alternatively reduces the possible current drain from the supply for a given drop in output voltage.

As mentioned previously, one 2A3 should be used for every 60-70 ma. that it is desired to draw from the supply, so that, in general, two in parallel should be quite enough for all normal purposes. Increasing the number past two has mainly the effect of improving the regulator's performance at the higher voltages.

CONSTRUCTION

Since only power frequencies and D.C. are being handled, circuit layout is not very important. Components may be mounted in any convenient position, the only proviso being that if more than one 2A3 is used, these tubes should be placed as close together as possible without touching, so that the leads connecting the grids and plates in parallel may be as short as possible.

Since the regulator is in reality a two-stage amplifier, in which stray and inter-electrode capacities in the second stage are quite high if a number of 2A3's are used, it is possible for the regulator section to oscillate at some high or audio frequency. This is particularly liable to happen if more than two 2A3's are connected in parallel. However, as the cure is a simple one, the possibility of oscillation need not be regarded as a drawback to the circuit. All that needs to be done to prevent oscillation, should it take place, is to connect grid-stoppers in series with each 2A3 grid pin. These have not been drawn on the circuit diagram, as the parallel tubes have been shown as a single one, for the sake of clarity. The way to connect the stoppers, which should have some high value—50k. or more—is to solder them directly to the grid pins of the 2A3's. The free ends are then connected in parallel and are taken to the plate of the 6SJ7.

A further precaution, which may be found necessary when the supply is used to power an R.F. oscillator, is to put an R.F. choke in the positive lead from the supply, bypassed at one end by a small mica condenser, say, 0.0001 mfd., rated at 1000 volts or more.

If these two precautions are taken, it is exceedingly unlikely that any trouble will occur.

SMOOTHING

A single section filter has been used, and even if a very pure supply voltage is required, a second section is neither necessary nor desirable. The fact is that the regulator tubes, as well as smoothing out D.C. variations in the output, also remove any hum that may get through the filter, the action being exactly the same as that of the D.C. regulation. There will, however, be 2.5v. A.C. superimposed on

(Concluded on page 48.)

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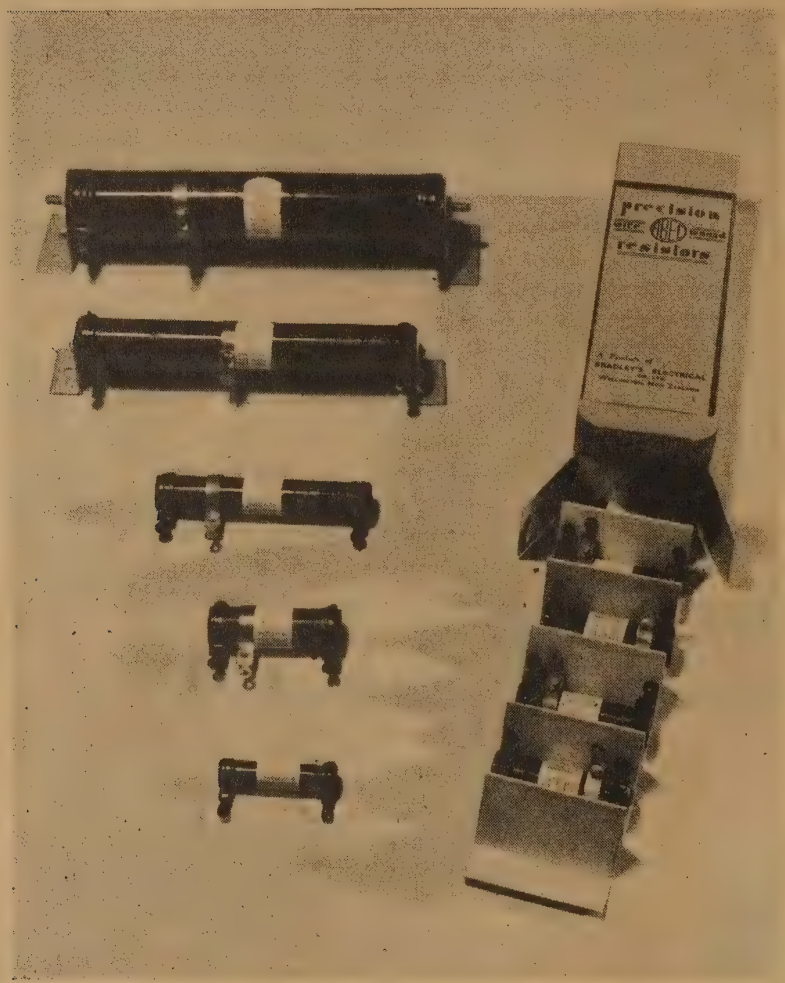

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QUESTIONS and ANSWERS

Feeding a 2-element collinear array on 3·5 mc/sec·

R.T.W., Ohakune, writes as follows:—

I have heard a good deal in favour of "two half-waves in phase" as a transmitting antenna. I have room for one, but my feeders must, for some distance (say, 50 feet), be of a low-impedance untuned type, as they must run close to an iron roof, etc. The antenna is primarily intended to be used on a 3.5 mc/sec. band.

The problem simply is how to feed it. If satisfactory, I should like to use parallel transparent P.V.C. I imagine that some sort of matching stub will be necessary to match feeders to antenna.

(1) Is such an antenna suitable for multi-band or wide-band operation?
(2) What is the approximate radiation pattern?
(3) Is P.V.C., as mentioned, suitable for feeders?
(4) What is the characteristic impedance of such P.V.C.?
(5) Are there any better types of feeder available?
(6) What matching arrangements are necessary, or suitable?
(7) Are there any unusual arrangements necessary for coupling the feeders to the final tank coil?
(8) What is the characteristic impedance at the centre of the antenna?

Taking the questions in order:—

(1) No. In common with almost all systems using untuned feeders, multi-band operation is not possible. With regard to wide-band operation, entirely adequate results will be obtained over the whole 80m. band if the aerial is cut and matched for the centre of the band. It is on this assumption that the dimensions given in the figure have been worked out.

(2) The horizontal radiation pattern will be approximately as in Fig. 2, which is the theoretical one for this type of aerial. In practice, the nulls will be somewhat filled in, and the lobes will not have exactly the right shape, owing to the proximity of buildings, trees, etc., but there is no need to attempt to take this into account.

(3) The wire mentioned is very suitable for the low-impedance feeders, as its electrical and weathering properties are far better than those of any other twin cable which is available, except, of course, the much more expensive double coaxial cable made specially for R.F. transmission lines. It is not generally known that ordinary P.V.C. covered wire has much smaller losses than any fabric and/or rubber-covered wire of similar dimensions.

(4) Since measurements on this wire are not available at the moment, the exact characteristic impedance is not known to us. However, it is safe to say that it will be between 70 and 150 ohms.

(5) No, unless twin coaxial is used, which would undoubtedly prove too expensive.

(6) The recommended matching arrangements are shown in Fig. 1, together with dimensions calculated for 3730 kc/sec. or the centre of the 80m. band. A quarter-wave matching transformer is used between the untuned feeders and the aerial. If the characteristic impedance of the untuned lines was accurately known, the dimensions of the transformer could all

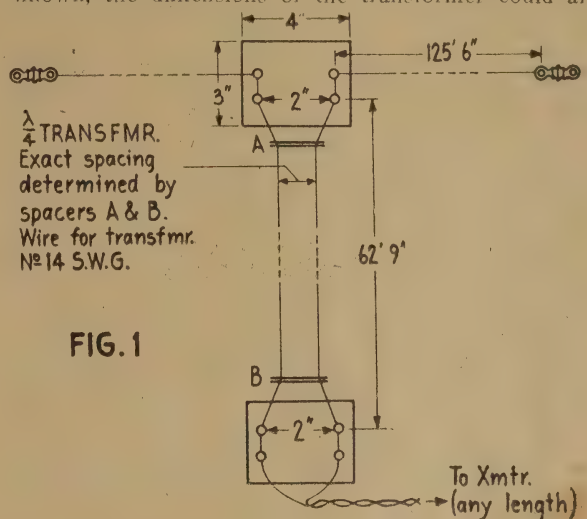

FIG. 1

Complete dimensions for the array referred to in the text. Each half of the flat top has the length shown. The spacers can be made of ⅛ in. perspex. The quarter wave transformer should be kept tight and should have spacers (not shown) every six feet or so.

be calculated in advance, and no adjustment would be necessary. As it is, the spacing of the wires of the quarter-wave transformer has been left unspecified, and by varying this an exact match can be obtained.

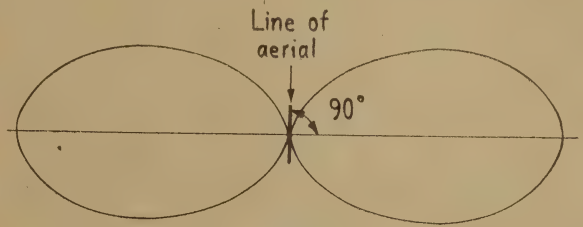

FIG. 2

Polar diagram that can be expected in the horizontal plane from this array. This is theoretical only, but will be closely approximated if the array is erected in the clear, away from buildings, power lines, etc.

The centre insulator may be made from a piece of perspex sheet, rectangular in shape, 4 in. x 3 in. An exactly similar spacer is used at the bottom end of the quarter-wave transformer, and this spacer is used in addition as an anchor for the low-impedance line. The spacing given will produce a perfect match between aerial and line in the event that the latter has

a characteristic impedance of 150 ohms. Since the actual figure is expected to be lower than this, it is most unlikely that a proper match will be obtained. However, the correct adjustment is made by bringing the wires of the transformer together with two auxiliary spacers so as to decrease the characteristic impedance of the transformer. When the right spacing has been determined experimentally, permanent spacers are made to hold the wires the correct distance apart, and these are installed at intervals of about six feet along the transformer. The wires of the transformer need not run vertically. This would be possible only if the flat-top was more than about 62 feet in height. The transformer must be at right-angles to the flat-top whatever happens, but may have any convenient slope and should be kept reasonably tight.

One way to tell when the transformer has been adjusted to the correct spacing is to couple the untuned line to the final tank circuit, and to vary the spacing of the transformer wires until maximum power is drawn from the final, as shown by maximum plate current. At each alteration of the spacing, the final tank circuit must be retuned to resonance before the current is read. Resonance is indicated as usual by **minimum** plate current as the tank is tuned, but at each adjustment and retuning the minimum will increase. The principle of the method is simply that as the aerial is brought into proper match with the untuned line, so it will draw more power from the final of the transmitter.

When the point of best match is passed, further decreasing the spacing of the transformer wires will result in decreased power being drawn from the final after the tank has been retuned.

The method outlined above entails a great deal of running about between the aerial and the transmitter, but if a field strength meter is available an easier method may be used. This is to tune the final tank to resonance, and then clip on the untuned feeders. After this, the final tank is left untouched, and the adjustment of the quarter-wave transformer is proceeded with until maximum field strength is shown by the meter.

Since the quarter-wave matching transformer will do a small amount of radiating, the field strength meter should not be located too close to it, otherwise no special precautions need be taken with this method. When the transformer has been finally adjusted with the field-strength meter, the final will be found to draw much more current than before the adjustment process was started. For this reason, the initial coupling between the untuned line and the final tank should be made quite small, so that the final will not be overloaded during the adjustment. Apart from this, the exact coupling at the transmitter will have no effect on the matching, and can be disregarded.

(Continued in next column.)

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MR. CORNEY INVESTIGATES

Each month we present a servicing problem all the relevant facts of which will be given by our tame investigator, "Mr. Corney" (with humble apologies to Inspector Hornley of BBC fame). Readers are invited to solve the problems and submit their ideas to our office, marking the envelope "Problem" in the top left-hand corner. Correct solutions will be given in each succeeding issue, together with the names of those whose efforts were successful.

No. 2. VANDALISM ON 2YA

Yes, we guessed right; old Brown was as hipped as a wet hen and stuttering with ire. Apparently he had just bought an A.C./D.C. superhet. from a chap and, although it wasn't so bad on other stations, on 2YA it was a washout. The humming and drumming just drowned the programme, unless the volume was turned right down. The fellow from whom he bought it didn't tune to 2YA, but extolled its virtues on the other "more difficult" stations! They say there is one born every minute—anyway, Brown went off to discuss legal action and what-not and left me with the baby. Shorting the grids of all the valves in turn cut out the hum, but shorting the aerial and earth terminals did not, so the pick-up seemed to be in the aerial coil, which was located amidships under the chassis—but then, why not any pick-up at other dial spots? There was some funny business here, and a search in the undergrowth was clearly indicated.

Well, to cut a long story short, when Brown returned, still frothing at the gills, I told him he hadn't done so badly after all, and proved it to him, which restored his faith in himself as a cute businessman. Excuse me, there's the phone——

SOLUTION TO LAST MONTH'S PROBLEM

The trouble with Williams's pet radio? Let me see now; where's my case-book? Oh, yes, here we are. It was simple enough, really—just one of those things that "simply don't happen," but do, if you know what I mean. Well, under the circs. it just had to be the first I.F. coil, so we unhooked the contraption and dug the innards out and found the lower coil had slipped down the former and so made no effective coupling with the upper one. If it had been one of those dipped-in-wax affairs, it wouldn't have happened. We just pushed the coil back to its original place and locked it with wax and off she went.

---

(7) No. Any of the usual arrangements may be used for coupling a balanced untuned line to the final tank.

(8) The antenna has an impedance of 1500 ohms at the centre.

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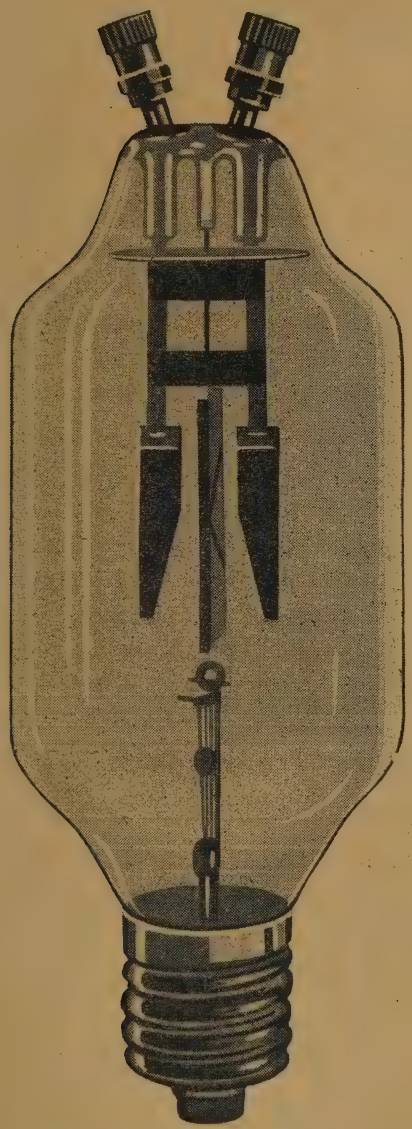

TYPE	D.C. OUTPUT AMPS.	ANODE VOLTS
328	1.3	2 x 28
451	1.3	2 x 16
367	6	2 x 45
1010	1.3	2 x 60
1037	6	2 x 60
1039	15	2 x 60
1049	25	2 x 60
1054	40	2 x 48
1059	40	2 x 60
1063a	6	3 x 250
1069	60	2 x 55
1089	10	2 x 60
1533	15	3 x 250
1534	15	2 x 275
1554	40	2 x 275
1710	3	2 x 130
1725	1.3	2 x 130
1729	6	2 x 95
1738	15	2 x 95
1749	25	2 x 95
1759	50	2 x 95
1768	6	2 x 275
1788	10	2 x 95
1849	25	2 x 95*

* Special long life type.

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INDEX TO "RADIO and ELECTRONICS"—Volume I

Subject	Issue No.	Page No.
Accurate Voltage Readings in High-impedance Circuits	11	11
A.C./D.C. 24-Range Multimeter, An	5	6
Aerials, A Matter of (Editorial)	10	2
Aerials for 10 Metres—Part I	6	13
Aerials for 10 Metres—Part II	7	13
A.F.C. Control Tubes (Questions and Answers)	5	11
A.G.L.T. (Automatic Gun-laying Turret) (Radar)	4	4
Amateur Band Receivers, Some Notes on the Design of—Part I	7	36
Amateur Band Receivers, Some Notes on the Design of—Part II	8	17
Amateur Experimenter, The (Editorial)	3	2
Amateur Transmitters' Modulator Using P-P807's, A 50-Watt	5	29
Amateur Transmitter's Modulator Using P-P807's, A 50-Watt	11	45
Amateur's Transmitter, A Four-band	11	8
Amateur's Transmitter, A Four-band	12	43
Amplifier-Gramophone, A Compact 4½-Watt	8	6
Amplifier, A High-quality 6A3	1	9
Amplifier, A 9-Watt Push-pull 6V6	9	36
Amplifier, An Experimental Two-stage I.F.	10	10
Amplifier, A Two-valve Battery Operated	10	19
Amplifiers, An Introduction to Wide-band—		
Part I	8	10
Part II	9	8
Part III	10	29
Application of Miniature Tubes, The—		
Part I	6	21
Part II	7	21
Atomic Energy	5	21
Automatic Gun-laying Turret—A.G.L.T. (Radar)	4	4
Back on All Bands (Editorial)	6	2
Bandspread Six, The	7	8
Beginners' Course, A Practical—		
Part I	5	34
Part II	6	36
Part III	7	46
Part IV	8	43
Part V	9	42
Part VI	10	42
Part VII	11	34
Part VIII	12	44
Bridge Type Capacity Analyser, A (by "Electron")	6	8
Broadcast Five, The Radel A.C.	4	27
Broadcast Tuner, A High-quality	9	6
Canterbury Project, The	3	25
Canterbury Project, The	8	33
Canterbury Project, The	11	23
Capacity Analyser, A Bridge Type (by "Electron")	6	8
Cathode Follower, The	1	22
Cathode Follower at High Frequencies	5	13
Checking Grid Bias Cells	2	36
Condenser Tester, A	1	21
Control Tubes, A.F.C. (Questions and Answers)	5	11
Converter, A High-performance 10-Metre	4	6
Converter, A High-performance 10-Metre	5	39
Converter, The "Radio and Electronics" 10-Metre (Letters to the Editor)	10	46
Counter, Geiger Mueller (by J. F. McCahon)	10	4
Design of Amateur Band Receivers, Some Notes On—		
Part I	7	36
Part II	8	17
Design of Reactance Tube Circuits	11	21
Design Sheet No. 1—Matching-Transformer Ratios	3	20
Design Sheet No. 2—Volts, Ohms, Milliamps, Watts	6	28
Design Sheet No. 3—Vented Loudspeaker Enclosures	9	30
Detector Circuits, Regenerative	5	37
Dielectric and Insulating Materials in Radio Engineering, New	9	47
Domestic Sets of To-morrow (Editorial)	7	2
Dry Cells, Testing with an Ammeter	7	20
Dual-Wave Five, The Radel A.C.	6	17
Dynamic Microphone, Preamplifier Circuit for (Questions and Answers)	8	36
Editorials—		
A Matter of Aerials	10	2
The Amateur Experimenter	3	2
Back on All Bands	6	2
Domestic Sets of To-morrow	7	2
Electronics in the Post-war World	9	2
The N.Z. Electronics Institute	8	2
What is Fidelity?	4	2
"Radio and Electronics," Vol. I, No. 1	1	2
Radio Servicemen's Examination	11	2
Techniques—British or American?	2	2
Television—When?	5	2
Training of Radio Servicemen, The	12	2
Electronics Institute, The N.Z.	7	20
Electronics Insttiute, The N.Z.	8	33
Electronics Institute, The N.Z.	9	39
Electronics Institute, The N.Z. (Editorial)	8	2
Electronics Institute, The N.Z. (News of Branches)	11	43
Electronics—What It Is and What It Does (by L. J. A. van Lieshout)	6	26
Electronics Age, The Rise of (by H. Lacey Hawkins)	10	14
Electronic Magnetiser, An (by N. V. Ryder and F. F. Evison)	9	12
Electron Microscope (Questions and Answers)	5	11
Electronics in the Post-war World (Editorial)	9	2
Errors and Omissions	5	44
Fault Caused by the Magic Eye, A	8	41
Fidelity?, What is (Editorial)	4	2
50-Watt Amateur Transmitter's Modulator Using P-P807's, A	5	29
50-Watt Amateur Transmitter's Modulator Using P-P807's, A	11	45
Fishpond (Radar)	8	2
Frequency, Measurement of—Part I	1	30
Frequency, Measurement of—Part II	2	13
Frequency, Measurement of—Part III	3	30

Subject	Issue No.	Page No.
Frequency, Measurement of—Part IV	9	32
Frequency, Measurement of—Part V	10	34
Frequency, Measurement of—Part VI	11	17
Frequency, Measurement of—Part VII	12	46
Four-band Amateur's Transmitter, A	11	8
Four-band Amateur's Transmitter, A	12	43
Geiger-Mueller Counter (by J. F. McCahon)	10	4
Gen Box, H2S or the (Radar)	6	4
General Principles of Radar (Radar)	1	4
Gramophone Amplifier, A Compact 4½-Watt	8	6
Gramophone Pick-up Armatures, Centering	8	41
Grid Bias Cells, Checking	2	36
Heating, Radio Frequency (by Dr. L. Hartshorn)—		
Part I	7	30
Part II	8	28
Height-finding by Radar (Radar)	9	4
H2S or the Gen Box (Radar)	6	4
I.F. Amplifier, An Experimental Two-Stage	10	10
I.F. Frequencies for Domestic Receivers (Servicemen's Page)	3	34
Infinite Impedance Mixer, The	2	30
Infinite Impedance Mixer, Some Tests of the (by ZLZML)	5	26
Infinite Impedance Mixer Again (Questions and Answers)	12	34
Institute, N.Z. Electronics	7	20
Institute, N.Z. Electronics	8	33
Institute, N.Z. Electronics	9	39
Institute, N.Z. Electronics (Editorial)	8	2
Institute, N.Z. Electronics (News of Branches)	11	43
Institute of Radio Technology (N.Z.), Proposed	2	23
Insulating Materials in Radio Engineering, New Dielectric and	9	47
Introduction to Wide-band Amplifiers, An—Part I	8	10
Introduction to Wide-band Amplifiers, An—Part II	9	8
Introduction to Wide-band Amplifiers, An—Part III	10	29
Lancastrian, The Radio and Radar Equipment on	2	4
Magic Eye, A Fault Caused by the	8	41
Magnetiser, An Electronic (by N. V. Ryder and F. F. Evison)	9	12
Matching Transformer Ratios (Design Sheet No. 1)	3	20
Measurements D.C., A Vacuum Tube Voltmeter for	8	14
Measurement of Frequency—Part I	1	30
Measurement of Frequency—Part II	2	13
Measurement of Frequency—Part III	3	30
Measurement of Frequency—Part IV	9	32
Measurement of Frequency—Part V	10	34
Measurement of Frequency—Part VI	11	17
Measurement of Frequency—Part VII	12	46
Mica Mining	4	25
Microphone, Preamplifier Circuit Suitable for a Dynamic (Questions and Answers)	8	36
Miniature Tubes, The Application of—Part I	6	21
Part II	7	21
Modulator, A 50-Watt Amateur Transmitter, Using P-P807's	5	29
Modulator, A 50-Watt Amateur Transmitter, Using P-P807's	11	45
Multi-carrier V.H.F. Communications System, A (by M. G. Scroggie)	11	4
Multimeter, An A.C./D.C. 24-Range	5	6
N.Z. Electronics Institute	7	20
N.Z. Electronics Institute	8	33
N.Z Electronics Institute	9	39
N.Z. Electronics Institute (Editorial)	8	2
N.Z. Electronics Institute (News of Branches)	11	43
N.Z. Institute of Radio Technology, Proposed	2	23
Nine-watt Push-pull Amplifier, A	9	36
Oboe, A High-precision Radar System (by M. G. Scroggie)	7	4
Operation of Triode and Pentode Power Units (Tube Data)	12	26
Oscilloscope, A 5in. Service—Part I	2	7
Oscilloscope, A 5in. Service—Part II	3	7
Oscilloscope, A 5in. Service—Part III	4	17
Pentode Power Tubes, Operation of (Tube Data)	12	26
Plan Position Indicator (P.P.I.) (Radar)	3	4
Plastics, The Romance of	12	4
Police Radio, Mobile (by M. M. Macqueen)	2	15
Post-war Receivers (Letters to Editor)	6	12
Power Supply from the Mains	12	21
Practical Beginners' Course, A—Part I	5	34
Part II	6	36
Part III	7	46
Part IV	8	43
Part V	9	42
Part VI	10	42
Part VII	11	34
Part VIII	12	44
Practical Trouble-shooting (by C. R. Leslie)—Part I	11	37
Practical Trouble-shooting (by C. R. Leslie)—Part II	12	31
Pre-amplifier Circuit Suitable for Dynamic Microphone (Questions and Answers)	8	36
Pre-amplifier for Moving Coil Pick-up	12	9
Pre-amplifier Suitable for Use with a P.E. Cell (Questions and Answers)	6	16
"Progressive" Battery Three, The Radel—Part I	6	32
Part II	7	41
Part III	8	34
Part IV	9	26
(Letters to the Editor)	11	44
Propagation at 10 Metres	4	13
Publications Received:		
Cossor Frequency Modulated Ganging Oscillator	11	47
Cossor Model 339 Double-bead Oscillograph	11	47
Electronics in Industry	10	39
G.E. Electronic Tube Manual	10	39
Mazda Valve Data	2	34

Subject	Issue No.	Page No.
Philips Technical Review	9	47
Radiotron Characteristics Chart	2	34
Radiotron Equivalent Types Chart	2	34
Radiotronics Digest	2	34
Radar Articles:		
A.G.L.T.	4	4
Fishpond	8	4
General Principles	1	4
Height-finding by Radar	9	4
H2S, or the Gen Box	6	4
Japanese Style	5	4
The Lancastrian	2	4
Oboe—A High-precision Radar System (by M. G. Scroggie)	7	4
P.P.I.	3	4
Radel A.C. Broadcast Five, The	4	27
Radel A.C. Dual-wave Five, The	6	17
Radel One, The	2	25
Radel One, More About the	3	23
Radel "Progressive Battery Three"—		
Part I	6	32
Part II	7	41
Part III	8	34
Part IV	9	26
(Letters to the Editor)	11	44
Radel "Vibrator Four," The	12	17
Radio Energy, The Sun's (by Dr. F. E. S. Alexander)	1	16
"Radio and Electronics," Vol. I, No. 1 (Editorial)	1	2
Radio Frequency Heating (by Dr. L. Hartshorn)—Part I	7	30
Radio Frequency Heating (by Dr. L. Hartshorn)—Part II	8	28
Radio, Mobile Police (by M. M. Macqueen)	2	15
Radio Technology (N.Z.), Proposed Institute of	2	23
Radio Servicemen's Examination (Editorial)	11	2
Reactance Tube Circuits, The Design of	11	21
Regenerative Detector Circuits	5	37
R.F. Amplification in Receivers, A New Circuit Using Triodes for	12	13
Rise of the Electronics Age (by H. Lacey Hawkins)	10	14
Romance of Plastics	12	4
Servicemen's Page—		
Columbus Model 35	12	33
H.M.V. Models 465 and 465D	7	19
H.M.V. Model 467D	9	40
I.F. Frequencies of Domestic Receivers	3	34
5v. Pacemaker Receiver Model 515D	5	42
Philips Radioplayer Model 540	8	40
Philips Radioplayer Model 540E	10	44
Philips Radioplayer Model 593	4	39
Service Section—		
Practical Trouble-shooting (by C. R. Leslie)—Part I	11	37
Practical Trouble-shooting (by C. R. Leslie)—Part II	12	31
Service Tube Tests (by Engineering Div. Aerovox Corp.)—Part I	10	26
Service Tube Tests (by Engineering Div. Aerovox Corp.)—Part II	11	26
Service Tube Tests (by Engineering Div. Aerovox Corp.)—Part III	12	39
Signal-to-Noise Ratio	2	21
Speakers, Single or Dual (Questions and Answers)	12	34
Sun's Radio Energy, The (by Dr. F. E. S. Alexander)	1	16
Techniques, British or American (Editorial)	2	2
Television—When? (Editorial)	5	2
Ten Metres, Aerials for—Part I	6	13
Ten Metres, Aerials for—Part II	7	13
10-metre Converter, A High-performance	4	6
10-metre Converter, A High-performance	5	39
10-metre Converter, The "Radio and Electronics" (Letters to the Editor)	10	46
Ten Metres, Propagation at	4	13
Tester, A Condenser	1	21
Testing Dry Cells with an Ammeter	7	20
Training of Radio Servicemen, The (Editorial)	12	2
Transformer Ratio, Matching (Design Sheet No. 1)	3	20
Transmitter, A Four-band Amateur's	11	8
Transmitter, A Four-band Amateur's	12	43
Triodes for R.F. Amplification in Receivers, A New Circuit Using	12	13
Triode and Pentode Power Tubes, Operation of (Tube Data)	12	26
Tube Data:		
The E.B.C. 33 Duo-diode Triode	11	12
Type ECH35 Triode Hexode	8	21
Type EF39 R.F. Pentode	9	21
Type EL33 Power Pentode	10	21
Operation of Triode and Pentode Power Tubes	12	26
VR150/30 and its Companion Types	1	34
Tube Tests, Service—Part I	10	26
Tube Tests, Service—Part II	11	26
Tube Tests, Service—Part III	12	39
Tuner, A High-quality Broadcast	9	6
Two-valve Battery-operated Amplifier	10	19
Vacuum Tube Voltmeter for D.C. Measurements	8	14
Vented Loudspeaker Enclosure, Design of (Design Sheet No. 3)	9	30
V.H.F.—A Multi-carrier Communications System (by M. G. Scroggie)	11	4
Vibrator Four, The Radel	12	17
Voltage Readings in High-impedance Circuits, Accurate	11	11
Volts, Ohms, Milliamps., Watts (Design Sheet No. 2)	6	28
Volume Expander, An Improved	3	15
Wavemeter, An Absorption	1	27
Wide-band Amplifiers, An Introduction to—Part I	8	10
Wide-band Amplifiers, An Introduction to—Part II	9	8
Wide-band Amplifiers, An Introduction to—Part III	10	29
ZCI, Can I Use?	9	29
ZC1 Mark II Transmitter Receiver	9	17
ZC1, More About the (by Ralph Slade, ZL2BK)	11	13

THE HK24 TRANSMITTING TRIODE

Of recent months, numerous amateurs have purchased HK54's, but there has been a dearth of information on their characteristics and operating conditions. The data supplied in this article, therefore, should be of value to a number of our readers.

General

The Heintz and Kaufman HK54 is a triode transmitting tube having a rated maximum plate dissipation of 50 watts. It is specially designed for ultra-high-frequency use, and is therefore ideal as a final amplifier in transmitters on any amateur band below 200 mc/sec. It has very low inter-electrode capacities for a tube of its power rating, and an amplification factor of 27. It operates at full ratings up to 30 mc/sec., and at 56 per cent. of maximum input at 200 mc/sec.

It is small in physical size, and has both grid and plate connections brought through the envelope. The plate is brought out at the top, while the grid pin comes out at the side. The tube, therefore, is very suitable for circuits which use the transmission line type of tuned circuit. The low inter-electrode capacities also make neutralisation easy at the higher frequencies. Data and operating conditions follow.

PHYSICAL DATA

Plate	Cylindrical Tantalum
Grid	Braced Vertical Bar Tantalum
Filament	Thoriated Tungsten
Base	4-Prong (Isolantite) UX Base
Net weight	2½ ounces
Shipping weight	8 ounces
Maximum height	5¾ inches
Maximum diameter	2 inches

ELECTRICAL DATA

Filament voltage	5.0 volts
Filament current	5.0 amps.
Normal plate dissipation	50 watts
Maximum average plate current	150 ma.
Maximum average grid current	30 ma.
Maximum plate voltage	3000 volts
Average amplification factor	27

INTER-ELECTRODE CAPACITANCES

Grid-plate	1.8 mmf.
Grid-filament	2.1 mmf.
Plate-filament	0.5 mmf.

ULTRA-HIGH FREQUENCY PERFORMANCE

Class C Unmodulated:

FREQUENCY	30	60	120	200 mc.
Max. input	250	215	180	140 watts
Max. plate volts	3000	2700	2500	2000 volts
Typical plate efficiency	80	77	72	64 per cent.

Class C Plate Modulated:

Max. input	210	180	150	115 watts
Max. plate volts	2500	2200	2000	1700 volts

RADIO FREQUENCY POWER AMPLIFIER CLASS C UNMODULATED*

	Maximum Rating per Tube	Typical Operation, 1 Tube			
Power output	—	250	210	156	100 watts
Driving power	—	10	9	7	6 watts
D.C. plate voltage	3000	3000	2000	1500	1000 volts
D.C. plate current	150	100	130	135	135 ma.
D.C. grid current	30	25	20	20	20 ma.
D.C. grid voltage	—750	—290	—269	—150	—130 volts
Peak R. F. grid voltage	—	465	465	324	304 volts
Plate dissipation	50	50	50	46	35 watts
Plate input	300	300	260	202	135 watts

*Carrier conditions for telegraphy.

RADIO FREQUENCY POWER AMPLIFIER CLASS C PLATE MODULATED*

Power output	—	185	180	147	92	watts
Driving power	—	8	9	9	9	watts
D.C. plate voltage	2500	2500	2000	1500	1000	volts
D.C. plate current	125	90	110	125	125	ma.
D.C. grid current	30	20	25	30	30	ma.
D.C. grid voltage	—750	—250	—250	—140	—130	volts
Peak R. F. grid voltage	—	422	422	310	295	volts
Plate dissipation	40	40	40	40	35	watts
Plate input	225	225	220	188	125	watts

*Carrier conditions for 100 per. cent. modulation and 60 per cent. average value.

AUDIO FREQUENCY POWER AMPLIFIER CLASS B*

	Maximum Ratings Two Tubes	Typical Operation, 2 Tubes			
Power output	—	275	260	200	140 watts
Driving power†	—	10	12	10	10 watts
D.C. plate voltage	2500	2500	2000	1500	1000 volts
D.C. plate current, zero signal	—	20	24	40	40 ma.
D.C. plate current, max. signal	300	150	180	198	233 ma.
D.C. grid voltage	—	—85	—70	—45	—25 volts
Peak A.F. grid to grid voltage	—	360	360	300	295 volts
Plate dissipation	100	100	100	96	91 watts
Plate input, max. signal	375	375	360	296	233 watts
Load resistance, plate to plate	—	40000	36000	16800	8500 ohms
Driver transformer ratio (full secondary to full primary)‡	—	0.75	0.75	0.6	0.6

*All data for two tubes.

†Instantaneous power at crest of cyle; effective power is half of this value.

‡Driver tubes 2-6V6 Class A1. Plate volts 315. The use of inverse feedback is recommended to reduce distortion.

Make sure that your new set is fitted with a Rola "Anistropic" speaker. They are the first speakers to incorporate war-time research.

A NEW METHOD FOR PRODUCING RADIO SETS

By Ian Cox.

Recently the meeting of the British Institution of Radio Engineers had the largest attendance possible when Mr. J. A. Sargrove, one of Britain's leading experts in the electronic field, read a paper describing his new electronic circuit-making equipment known more shortly as "Ecme." By means of this system it is now possible to produce special radio sets at the rate of one every twenty seconds.

The average man with no radio engineering background is normally observant enough to appreciate that his radio receiver is a device built up of a number of dissimilar prefabricated parts, varying in intricacy from an ordinary piece of wire to a thermionic valve. He will appreciate, too, that many thousands of processes must have been completed after the manufacture of these parts before the radio set he sees came into being—processes not only concerned with assembly but with testing at various stages to ensure that various components are still sound, and wiring correct.

The novelty of Mr. Sargrove's Ecme is that it employs mechanised production methods to the full, and at the same time is subject to automatic electronic control so that, as well as the complete circuit arrangement and components of the set being produced automatically, automatic electronic testing is carried out while this is going on.

As an example of the method, the special radio set at present being manufactured may be taken. Basically it consists of two "insulated plates," the cabinet and a very few ancillary parts (valves, loudspeaker and electrolytic capacitors) which are not automatically produced. The principle of the method is the deposition of metal and graphite in the grooves in the plates and cabinet. This, of course, presupposes a most intricate and accurate design beforehand but I intend at this minute to give only an indication of the general method of production, and therefore will begin by considering the manufacture of the insulated plate. This, in a normal set, is little more than a supporting device, but in Mr. Sargrove's set it also forms the dielectric of the capacitors and is therefore an integral part of the circuit and pre-determines the characteristics of the other elements. The plate is moulded in plastic material and the structural form is so designed that when fully processed it contains the inductors, capacitors, resistors, potentiometer track, terminals and conductor paths. All of these are inter-related and inter-connected; they are "grown," as it were, on the original insulating plate in a continuous chain of electronically-controlled automatic processes.

Let us follow the processes rapidly through from one chamber to the next in Ecme. The insulated plate arrives ready moulded to the required design with grooves and depressions on both sides. First of all the surface moisture is dried off by irradiation of infra-red rays. The surface of the plate is then roughened with abrasive grit, so that the molten metal will stick to it, and then cleaned. In the next chamber this molten metal is sprayed on both sides of the plate by electronically-controlled pistols. The next process is milling, conducted at a high speed with diamond-cutting tools, which gradually removes the metal from the faces of the plate and leaves it only in the grooves and depressions of the moulding. This is the first stage in "growing" the circuit on to the plate and it is tested automatically in the machine before being allowed to pass on. Plates with faulty circuits are rejected without the remainder of the batch being held up.

The next steps are the spraying on of graphite for resistors through a stencil and the cleaning of unwanted material from the slots, etc. After this, Ecme automatically inserts metal sockets for the valves and so on, and once again the job is automatically tested and faulty plates rejected. The plate is then subjected to an overload electrical and thermal aging process, which increases its stability and reliability, and after this is sprayed with lacquer to seal it off. This completes the first of a series of processes, all of which are carried out in enclosed machinery.

The few prefabricated components — moveable vanes of semi-variable capacitors, valves, etc.—are next added to the plate and once again tests are carried out.

Meanwhile the branch-conveyor machines have produced the metal inserts (for example, mains plug and switch parts) in pre-moulded recesses and grooves in the cabinet of the set. These inserts and strips are then connected by graphite spraying and subsequent burnishing, which produces the main voltage dropping resistor within pre-determined parts of the cabinet. After this the cabinet and its components undergo electrical and thermal aging just as the insulated plates did. Then there is a further test, after which the plates are inserted in the cabinet, automatic electrical contact being made as this occurs. Finally there is a test of the whole set for signal reception.

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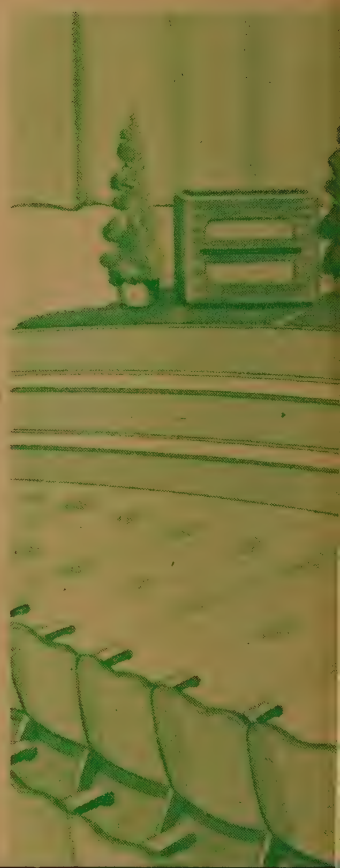

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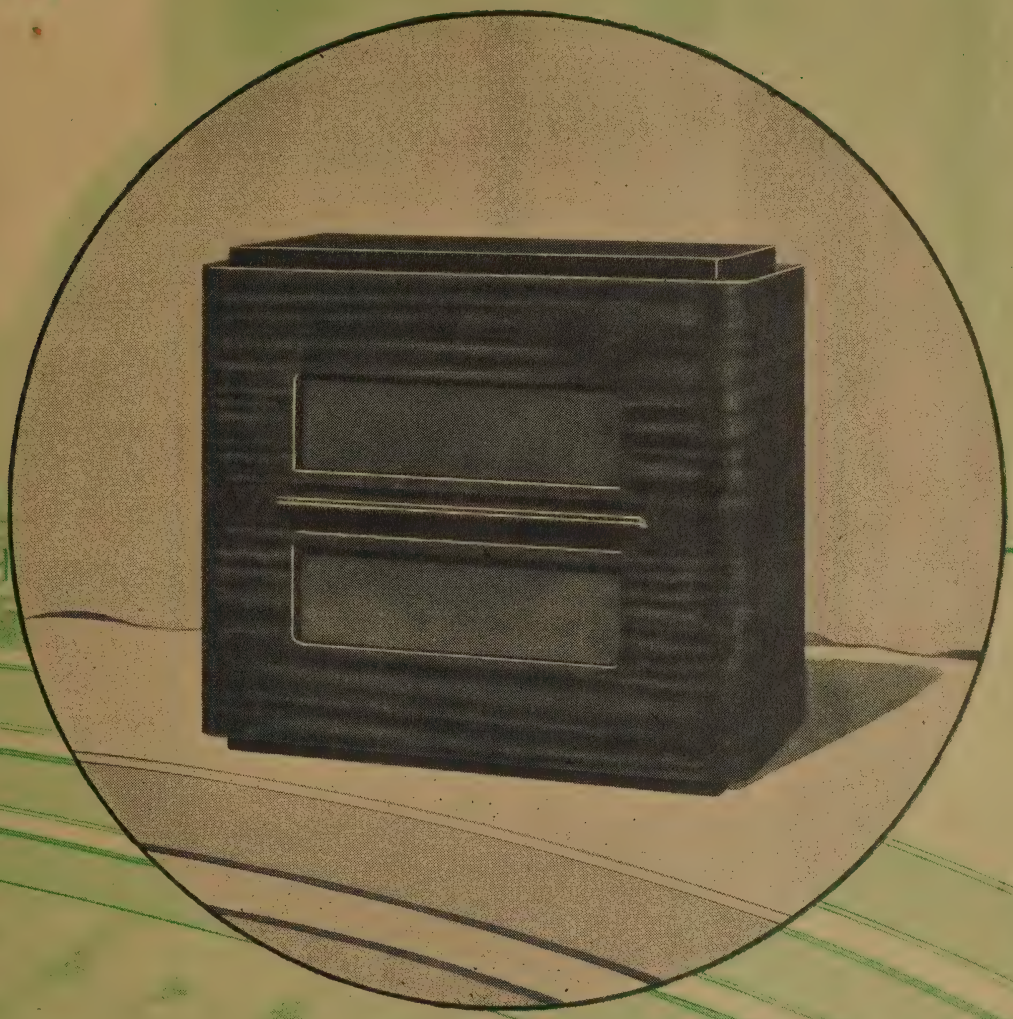

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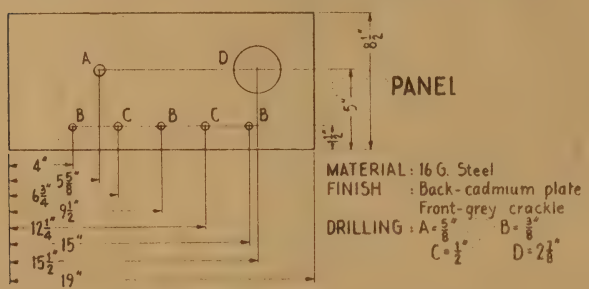
PART II—THE CIRCUIT IN DETAIL

Part I of this article described the tube line-up and the general considerations involved in arriving at the complete design. In this part will be found a discussion of the detailed circuit arrangements, and the data required in order to have the original chassis work duplicated.

THE FIRST I.F. STAGE

We have already discussed the purpose of the double triode first R.F. stage and the part it plays in improving the signal-to-noise ratio of the receiver. The circuit is the one given in a previous article in "Radio and Electronics" (March, 1947), and includes the modification, also indicated in the original article, which allows A.V.C. to be applied to it. The cathode inductance L_1 is a 10 mH. broadcast band choke as previously recommended for this circuit, while a 1500-ohm grid stopper R_1 has been included to prevent possible instability should the self-resonant frequency of the choke lie within the broadcast band.



Working drawing for front panel.

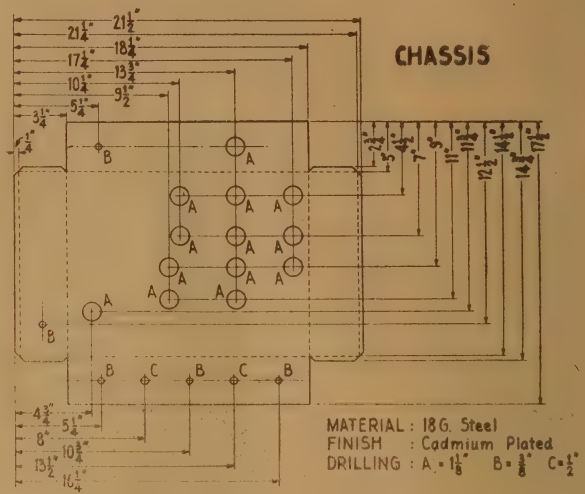
Note that, in common with all other H.T. leads to the R.F. end of the set, the two H.T. leads to the 6SN7 R.F. stage are bypassed with 0.05 mfd. condensers and decoupled with 2k. ½-watt resistors. In a set of this nature complete decoupling in this manner is absolutely essential if instability is to be prevented, and it must be at all costs. Although this comprehensive decoupling increases considerably the number of small parts used, none of it should on any account be omitted, for a set which is not quite stable is a dead loss as far as efficient operation is concerned.

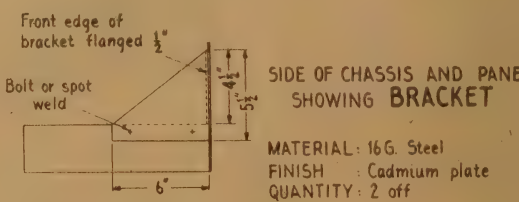
T_1 and T_2 are normal aerial and R.F. broadcast coils with high impedance primaries. R_3 provides a minimum bias for the 6SN7 of 7½ volts, and R_4 is the A.V.C. decoupling resistor of 50k., the free end of which goes to the A.V.C. line which provides one-half of the available A.V.C. voltage.

At this point it should be noted that the variable condensers (unmarked) shown across the secondaries of T_1, T_2, T_3, and T_4 are sections of the four-gang variable condenser. No trimmers have been shown on the diagram, for the sake of clarity, but, as the gang condenser has no built-in trimmers, these have to be provided. Four 3-30 mmfd. air-dielectric Philips-type trimmers are used, one for each section of the gang. These are connected directly to ground from the "high" end of each grid coil in the R.F. end. Their placement will be discussed later.

SECOND R.F. STAGE

There is nothing unusual about the circuit of this stage. Unlike V_1, the tube is controlled both by the A.V.C. and the manual gain control. C_5 bypasses the cathode circuit, and R_7 ensures that a minimum of 500 ohms is placed in the cathode circuit of V_2. The end away from the cathode is taken off to




Front edge of bracket flanged ½"
Bolt or spot weld
SIDE OF CHASSIS AND PANEL SHOWING BRACKET
MATERIAL : 16 G. Steel
FINISH : Cadmium plate
QUANTITY : 2 off
6"

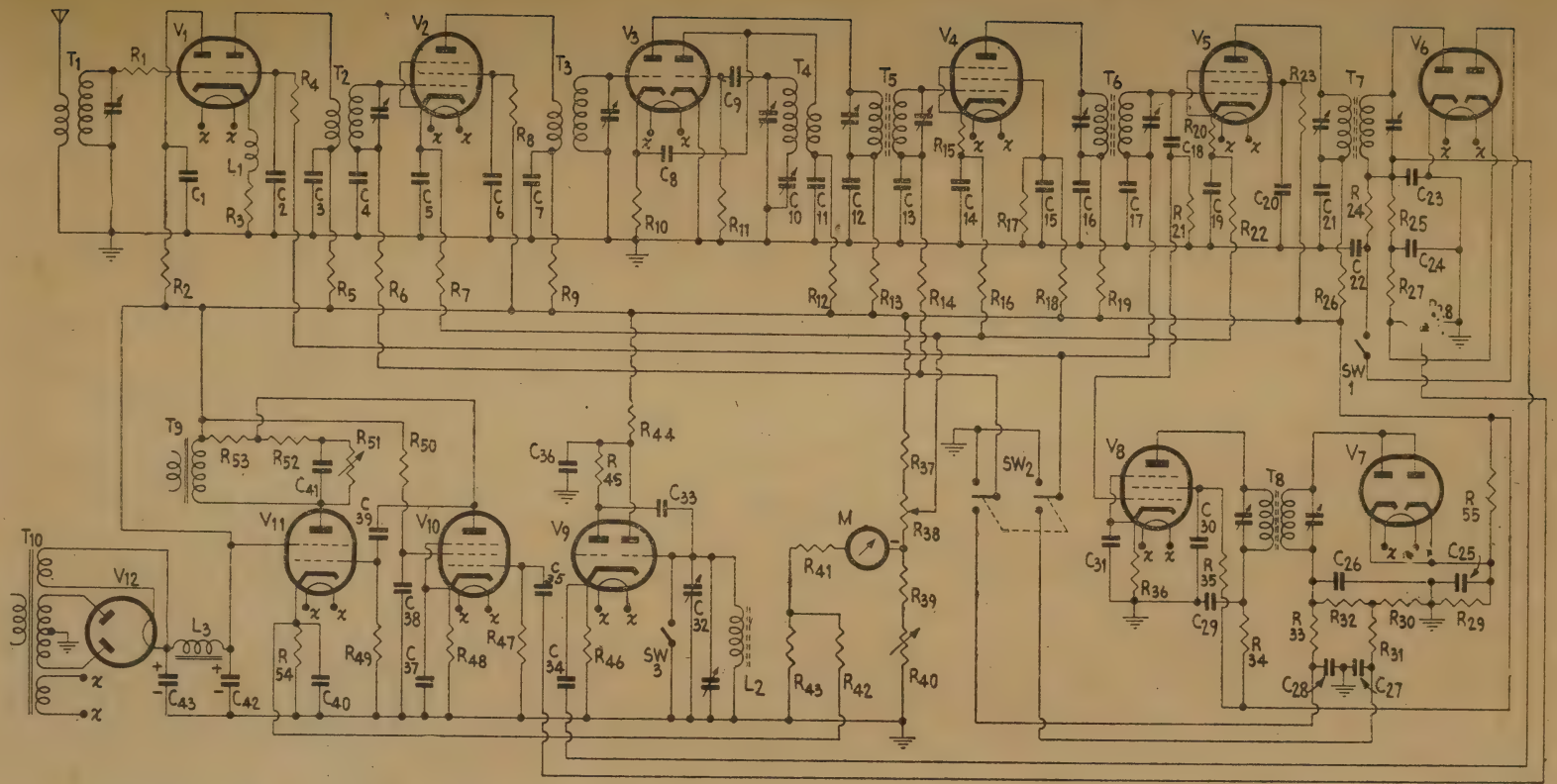
Working drawings for chassis and panel mounting bracket.

the moving arm of R_{3a}, the manual gain control potentiometer. The plate circuit is decoupled with the usual 0.05 mfd. condenser and 2k. resistor, and the screen supply is from H.T. via a 100k. dropping resistor.

Attention should here be drawn to an error in the circuit diagram of this stage. The grid tuning condenser has been drawn showing the lower plates connected directly to the "cold" end of the grid coil. This is clearly impossible, since the frame of the gang condenser automatically returns this section to earth, which is how it should be shown on the diagram.

OSCILLATOR MIXER

V_3, a further 6SN7, is used as oscillator and infinite impedance mixer. The latter part of the circuit is quite normal, and uses a 100k. cathode resistor in the usual way. The oscillator, unlike the circuits so far published for use with the infinite impedance mixer, uses the straightforward tickler feedback cir-



Resistances: R_1, R_{16}, R_{22} = 1500 ohms; R_2, R_5, R_9, R_{13}, R_{19}, R_{26}, R_{34} = 2000 ohms; R_3, R_7, R_{48}, R_{54} = 500 ohms; R_4, R_{11}, R_{14}, R_{17}, R_{25}, R_{30}, R_{32}, R_{44}, R_{45}, R_{37} = 50k.; R_6, R_8, R_{10}, R_{23}, R_{27}, R_{35}, R_{53} = 100k.; R_{12}, R_{18} = 25k.; R_{15}, R_{20} = 150 ohms; R_{21}, R_{49}, R_{50}, R_{52} = 500k.; R_{24}, R_{33}, R_{47} = 1 meg.; R_{28} = 1 meg. potentiometer; R_{29} = 10k.; R_{31}, R_{55} = 250k.; R_{36} = 4000 ohms; R_{39}, R_{43} = 200 ohms; R_{40} = 100-ohm potentiometer; R_{41} = 3000 ohms; R_{42} = 350 ohms; R_{46} = 5000 ohms; R_{38} = 10k. potentiometer; R_{51} = 2 meg. potentiometer.

Condensers: C_1, C_4, C_{17}, C_{25} = .02 mfd.; C_3, C_5, C_6, C_7, C_{11}, C_{12}, C_{36} = .05 mfd.; C_2, C_{13}, C_{14}, C_{16}, C_{19}, C_{20}, C_{21}, C_{22}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{35}, C_{38}, C_{39} = .1 mfd.; C_8, C_9, C_{23}, C_{24}, C_{26} = .0001 mfd.; C_{33} = .00001 mfd.; C_{10} = 600 mmfd. padder; SW_3 = B.F.O. on/off (see text) C_{15} = .005 mfd.; C_{18} = .00005 mfd.; C_{32} = 2–10 mmfd. variable; C_{41} = .001 mfd.; C_{37}, C_{40} = 25 mfd. 25v. electrolytic; C_{42}, C_{43} = dual 8 mfd. electrolytic; C_{34} = two pieces of push back wire twisted together for ½ inch.

Valves: V_1, V_3 = 6SN7GT; V_2, V_5, V_8 = EF39; V_4 = 6SK7; V_6, V_7 = 6H6; V_9 = 6N7; V_{10} = 6SJ7; V_{11} = 6V6; V_{12} = 80.

Switches: SW_1 = toggle switch S.P.S.T.; SW_2 = toggle switch D.P.D.T.

Meters: M = 0–1 m.a.

Transformers: T_5, T_6, T_7, T_8 = 465 kc. I.F.'s; T_9 = speaker transformer; T_{10} = power transformer, 385-0-385v.—6.3v. —5v.; L_2 = B.F.O. coil; T_1, T_2, T_3 and T_4 = aerial, R.F., and osc. coils. See text of next instalment.
L_1 = 10 mH. broadcast choke; L_3 = 1500 ohm speaker field.

cuit. This enables a standard oscillator coil to be used, and has no adverse effect on either oscillator or mixer performance. In this case the oscillator voltage is fed to the mixer cathode from the oscillator plate through a 0.0001 mfd. coupling condenser, C_8.

C_{10} is the usual 100 mmfd. (**not** 10 mmfd., as stated in the original component list). No. A.V.C. is provided on the mixer, as this circuit is unsuitable for volume control of any sort.

THE I.F. AMPLIFIER

The first stage is a 6SK7, while the second employs an EF39. The latter is chosen for the second stage on account of its superior strong-signal performance, but a 6SK7 is used in the first stage so as to give an improved wiring layout. In particular, it avoids two top grid leads from adjacent I.F. transformers, with the attendant possibility of feedback and instability.

Both these stages are provided with both A.V.C. and manual control. On A.V.C., V_4 is provided with the full control voltage, while the grid return circuit of V_5 is taken to the "½A.V.C." line. Placing a portion only of the A.V.C. voltage on the second I.F. stage still further decreases the likelihood of distortion occurring on strong signals.

A point worthy of note is the biasing arrangement used for both V_4 and V_5.

First of all, it will be noticed that R_{15}, 150 ohms, is placed unbypassed directly in the cathode lead of V_4. The purpose of this is to provide a small amount of negative feedback, and thereby to decrease the variation of input capacity of the tube with A.V.C. voltage. This variation, caused by Miller effect, takes place in all A.V.C. controlled stages due to the change in gain itself. Normally, in R.F. stages, or in single-stage I.F. amplifiers, the detuning of the circuits caused by this variation of input capacity is too small to be of any consequence, owing to the comparatively low selectivity involved. However, in a two-stage I.F. amplifier, where the selectivity is much higher than normal, even a slight detuning of the circuits can make a noticeable difference to the amplification and necessitate retuning of the receiver. If the effect occurs while the A.V.C. is working hard, as in a deep fade, the result is very annoying. However, the unbypassed portion of the cathode resistor, in conjunction with the fact that both I.F. stages are running at well under maximum gain, reduces this potential "bug" to negligible proportions.

The input to V_8, the A.V.C. amplifier, is taken from the output winding of the second I.F. transformer T_6, through the 50 mmfd. condenser C_{18}. R_{21} is the grid leak for V_8, and, being 500k., produces negligible shunting on T_6.

MANUAL GAIN CONTROL

Manual gain adjustment is obtained with the 10k. potentiometer R_{38}, to the moving arm of which are taken the cathode return leads of V_2, V_4, and V_5. The high end of R_{38} is connected to H.T. through R_{37}, which ensures that the maximum positive voltage applied to the cathode of these three valves is approximately 40 volts. Since the cathode return circuits of the controlled tubes are quite separate from their grid circuits, manual control is effective whether or not the A.V.C. is switched on.

The two resistors R_{39} and R_{40} are included below the manual gain control so as to provide a control voltage for the signal-strength meter M, and at the same time to provide a small minimum bias for the manually-controlled tubes in addition to that given by the separate cathode resistors. The manual control circuit is so proportioned that, with the control fully clockwise, the overall gain of the receiver is held at a suitable level for the A.V.C. to give adequate control in the event of fading. It will be noted that manual control is not placed on the cathode of V_1, for, although the 6SN7, being a double triode, has a somewhat extended cut-off, the latter is not sufficiently remote to allow the full control voltage to be applied. The mixer, of course, cannot be manually controlled either.

THE SECOND DETECTOR AND NOISE LIMITER

The 6H6 V_6 acts in both the above capacities. The left-hand diode is the second detector, while the right-hand one of this tube is the noise limiter. Inspection of the circuit will show that if R_{24} were disconnected, and R_{27} short circuited, the detector circuit would be the conventional one in which R_{29} is the diode load resistor, and R_{25}, together with C_{23} and C_{24}, forms the filter, which keeps residual radio frequencies from entering the audio amplifier. R_{28} is a potentiometer, the moving arm of which taps off the audio voltage that is fed to the A.F. amplifier and therefore acts as the audio gain control.

Examining the circuit further to see how the noise-limiter diode works, it is found that R_{24} and C_{22} form an audio filter at the output of which appears only the D.C. voltage developed in the load circuit of the diode by the carrier being received. This D.C. voltage is applied through the on/off switch SW_1 to the plate of the limiter diode. The cathode of this diode is returned to the junction of R_{27} and R_{28}. When SW_1 is open, the diode plate is entirely disconnected from the circuit. The cathode, however, by virtue of the point to which it is connected, has applied to it a proportion both of the D.C. voltage developed in the detector load circuit and an equal proportion of the audio voltage developed at the same point. But since the limiter plate is disconnected, the diode has no effect on the operation of the detector circuit.

However, when SW_1 is closed, the situation is rather different. Now we have on the plate of the limiter diode a negative bias equal to the D.C. voltage developed by the carrier in the diode load circuit. The first point is that now the limiter will still have no effect as long as its cathode does not move sufficiently positive to allow it to pass current. The second and most important point is that the D.C. bias applied to the limiter plate is (to a close approximation) equal to the carrier level applied to the detector diode, and at the same time to the peak audio voltage when the carrier is modulated 100 per cent. Thus, although the limiter cathode is being moved in the positive direction on every audio cycle, the diode will not conduct unless the audio voltage exceeds the level reached by 100 per cent. modulation. Thus the limiter will have no effect on the

(continued on page 45)

Methods of Measuring Small Voltages

By the Engineering Division Aerovox Corporation

PART II

This increased current flowing in plate load resistor R_3 produces a voltage drop which may be read by means of a D.C. voltmeter, VM, or the plate current increment itself may be read by means of a D.C. milliammeter, MA. In order to prevent deflection of either meter by the steady static plate current of V_2, a bucking battery must be included (as in Fig. 1) in series with the voltmeter or in parallel with the milliammeter. The milliammeter scale, like that of the voltmeter, may be graduated in millivolts corresponding to the input potential range.

If the tubes and load resistors have the same specifications as those shown in Fig. 1 (i.e., Gm 11,000 and Rl 3500), the following ideal quantitative conditions might result: Application of 1-mv. D.C. potential to the input terminals results in a 0.011-ma. plate current increase in V_1. This increment produces a voltage drop of 38.5 mv. across the load

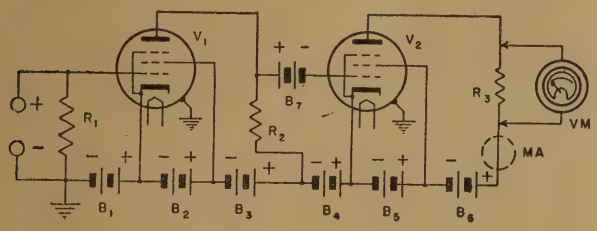


Fig. 2

resistor R_2, which is applied to the control grid of V_2. Application of this voltage produces a plate current increase of 0.423 ma. in V_2, and a corresponding voltage drop of 1.48v. across load resistor R_3. This last plate current increment may be made to actuate a milliammeter, MA, the scale of which is graduated in millivolts corresponding to the input potential range, or the incremental voltage drop across R_3 may be made to deflect a D.C. voltmeter, VM, the scale of which is graduated in a like manner.

It is not to be expected that the actual operation of the multi-stage D.C. amplifier is as simple as the foregoing discussion might indicate. This is especially true if a large number of tubes is employed. Small shifts in supply voltages, tube temperature, tube and component characteristics, and similar causes act singly or in combination to shift both the zero setting of the meter and voltage deflections.

Through the application of negative feedback, D.C. amplifier voltmeters have been made quite stable and sensitive. For example, one three-stage circuit has been designed (Brumbaugh and Vance of RCA) which gives a 1-milliampere deflection for 0.00022 microampere input. Another two-tube microvoltmeter designed for the Yale University School of Medicine by Sloans Physics Laboratory of Yale permits measurements of D.C. potentials down to 5 microvolts, and is used in studies of potentials in living organisms.

Potentiometer.—By means of a laboratory potentiometer, a small voltage may be compared with a somewhat larger standard voltage, and its value determined with precision.

The basic arrangement of the potentiometer circuit is shown in Fig. 3. R_1 is shown here as a single resistor, but in practical instruments it may consist of several resistance decades plus a close-reading slide-wire resistor, all connected in series. A battery is arranged to establish a current flow through R_1, the strength of this current being controlled by

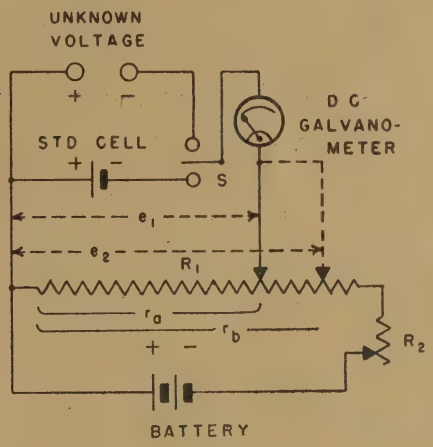


Fig 3

means of the rheostat, R_2. A variable contact on R_1 connects with a sensitive D.C. galvanometer and a single-pole, double-throw switch, S, which permits either a standard cell or the UNKNOWN VOLTAGE terminals to be connected in the circuit. Note that the standard cell (or the UNKNOWN VOLTAGE terminals) and the battery are connected in the circuit in opposing polarity.

Operation of the potentiometer is explained as follows: R_2 may be set for any arbitrary value of current flow from the battery through R_1 in which it produces a voltage drop. Switch S then may be thrown to the standard cell position; and since the cell and battery are in opposing polarity, the slider on R_1 may be set at a point where the opposing voltages reduce the galvanometer deflection to zero. At this point, the voltage drop e_1 along ra (that portion of R_1 between the positive terminal of the battery and the sliding contact) will be equal to the voltage of the standard cell (generally 1.01830v.).

Switch S may then be thrown to the upper position, connecting the voltage source of unknown value in the circuit in place of the standard cell. And the slider then may be moved to a new point along R_1 to reduce the galvanometer deflection again to zero. At this second null, the unknown voltage

will oppose exactly the voltage drop e_2 along rb (the new portion of R_1 between the positive terminal of the battery and the sliding contact). The unknown voltage (Ex) may be determined by means of the equation:

$$Ex = \frac{Es\ rb}{ra}$$

where Es and Ex are in volts and ra and rb are in ohms.

A simpler method which enables the unknown voltage value to be read from the direct-reading resistance dials of R_1 consists of the following procedure: The resistance ra is established at some convenient multiple, numerically, of the standard cell voltage, by pre-setting the slider. For example: ra may be made 1018.3 ohms for a standard cell voltage of 1.01830v. R_2 then is set for zero deflection of the galvanometer, this null indicating that the voltage drop e_1 is 1.01830v. Each ohm of resistance along R_1 then will be equal to 0.001v. or 1 mv. When the unknown voltage subsequently is switched-in in place of the standard cell and the second null adjustment is made, the reading of R_1 (as set) in ohms will indicate the unknown voltage value in millivolts. Similarly, if ra is made 1 megohm, each ohm along R_1 will indicate 1 microvolt.

Commercially available laboratory potentiometers are of rugged construction for the high sensitivity that they possess. These instruments are available in several types. The Wenner potentiometer (Leeds & Northrup) has been designed expressly for the highly precise measurement of low voltages, especially thermocouple potentials. In this instrument the fine control dial is graduated in steps of 0.1 microvolt on the low range for measurements between 0 and 0.0111110v. within a limit of error of plus or minus (0.01 per cent. + 0.1 microvolt).

INSTRUMENTS FOR A.C. MEASUREMENTS

d'Arsonval Meters.—Ruggedly-constructed, sensitive, movable-coil meters for measurement of small A.C. voltages are not available in the high sensitivities associated with D.C. instruments of the same type. These meters in the panel and bench d'Arsonval group commonly are D.C. microammeter movements connected in a bridge-type oxide rectifier circuit.

The lowest range generally supplied is 0-100 A.C. microamperes, with a scale length of 50 divisions. (Internal resistance, 4000 ohms.) In terms of voltage, the full-scale deflection of this meter is 400 mv. The smallest accurately-read deflection (half-scale division) is 4 mv.

Accuracy of the rectifier-type instrument is 4 per cent. of full scale on sinusoidal, or approximately sinusoidal waveforms, and at normal room temperature. The solid rectifier unit introduces a frequency error which is due mainly to its inherent shunting capacitance. This error causes the instrument reading to decrease as the frequency increases, and may amount to as much as 0.5 per cent. per kilocycle up to 20,000 cycles.

Semi-suspended A.C. Meters.—Laboratory, thermal milliammeters of the semi-suspended type are available with full-scale deflections as low as 0.5 ma. This type of instrument gives a typical voltage sensitivity of 3.75 mv. per scale division, with an internal resistance of 750 ohms. Since the thermal meter employs a thermocouple instead of an oxide rectifier, it may be employed with negligible error at higher frequencies than may the rectifier-type A.C. microammeter. At still higher frequencies (e.g., radio frequencies) scale corrections may be made.

A.C. Galvanometers.—Fully-suspended A.C. galvanometers of the lamp-and-mirror type are available with a typical highest sensitivity of 2 microvolts/mm. scale division for a scale-to-mirror separation of 1 metre.

Pointer-type A.C. galvanometers for laboratory bench use offer a best accuracy of 100 microvolts/mm. scale division.

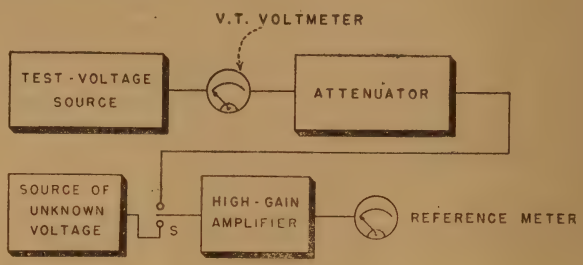


Fig 4

A.C. Amplifier-type Voltmeters.—The comparative ease with which high-gain A.C. amplifiers may be built and operated simplify the task of stepping up a tiny A.C. voltage to a value high enough to actuate a standard-range A.C. voltmeter.

For frequencies between 60 and 20,000 cycles, straight resistance-capacitance-coupled amplifier circuits may be used, and the number of stages, type of tubes, and operating voltages may be chosen (with the aid of resistance-coupled tube tables found in the tube manuals) to supply the required gain. An audio amplifier with 120 db. overall gain (voltage gain of 1,000,000 to 1), for example, will step 1 microvolt up to 1v., a value high enough to be read on a standard voltmeter scale. In high-gain instrument amplifiers, extraordinary care must be exercised to minimise hum and noise level, since the extraneous voltages introduced by these causes may easily equal the value of the unknown potential under measurement.

One commercially-available A.F. vacuum-tube voltmeter consists of a compact, power-line-operated high-gain amplifier terminated by a frequency-compensated oxide rectifier-type A.C. voltmeter. Response of this instrument is stated as flat from 10 cycles to 150 kc. Accuracy of the instrument is 2 per cent. of full scale. Lowest indication is 20 microvolts.

For frequencies between 20 cycles and 500 kc., flat operation may be obtained in an untuned amplifier by employing a standard video amplifier circuit. (See "Aerovox Research Worker," November, 1939, for video amplifier design instructions.) The upper frequency limit may be extended in these amplifiers to 4 Mc. by careful design. However, a plus or minus 1 db. variation in gain may be expected between 500 kc. and 4 Mc. in even the best video amplifier. Since it is necessary to operate video amplifier stages at reduced values of plate load resistance, a large number of stages may be required for a given overall gain. In order to cover the wide band of frequencies passed by the amplifier, the terminal instrument of the video amplifier voltmeter must be a V.T. voltmeter with high input impedance.

Tunable-Amplifier Voltmeters.—For general low-voltage measurements throughout the radio-frequency spectrum, it is desirable to employ a tuned-R.F. ampli-

fier. This unit will have no detector, but will be terminated by a low-range V.T. voltmeter with high input impedance. This is the arrangement used in the so-called channel analysers employed in radio trouble-shooting.

The tuned-R.F. amplifier type of voltmeter has the disadvantage that its gain is not constant for all frequencies in its tuning range. As a result, it becomes necessary to plot and keep a reliable curve showing gain levels at all frequencies, or to make a chart of gain-control settings which will maintain the overall gain at some fixed value.

Signal Comparison.—A small A.C. voltage of unknown value may be compared with a known voltage of the same frequency and its value determined by means of a calibrated attenuator arranged in a set-up of the type shown in block diagram in Fig. 4.

The source of unknown voltage is connected to the S.P.D.T. switch, S, together with the test-voltage source and its attenuator, so that either source may be connected at will to the input terminals of the high-gain amplifier. Both voltage sources must have the same frequency. If the voltages are of radio frequency, the test-voltage source will be a standard radio signal generator, the high-gain amplifier an all-wave superheterodyne radio receiver (operated without automatic volume control or a beat-frequency oscillator), and the reference meter an "intensity meter" operated by the D.C. component of signal voltage in the second detector circuit. If the voltages are of audio frequency, the test-voltage source will be a variable-frequency audio oscillator, the high-gain amplifier, a resistance-capacitance-coupled audio channel having an overall gain of 100-120 db., and the reference meter a high-impedance V.T. voltmeter conected across the amplifier output load resistor.

In operation, switch S is thrown to the left to connect the source of unknown voltage to the amplifier input terminals and the amplifier gain control is adjusted for some convenient steady deflection of the reference meter (e.g., centre scale). If the unknown voltage is at radio frequency, the signal must be tuned in sharply with the receiver, as indicated by peak deflection of the reference meter. The switch then is thrown to the right to connect the test-voltage source to the amplifier input terminals. (If measuring R.F., the receiver is not retuned for the test signal, but is left in its first adjustment and the test-voltage source tuned, instead, for peak deflection of the reference meter.) The test-voltage output control is adjusted for the standard attenuator input voltage (usually 1 volt R. M. S.), as indicated by the V.T. voltmeter. The attenuator then is adjusted until the deflection of the reference meter is the same as when actuated by the unknown voltage. At this point, the voltage reading of the attenuator indicates the value of the unknown voltage.

This substitution method may be employed for the measurement of very small A.F. and R.F. voltages. Standard attenuators operated at 1 volt input permit measurements between 1 microvolt and 0.1 volt.

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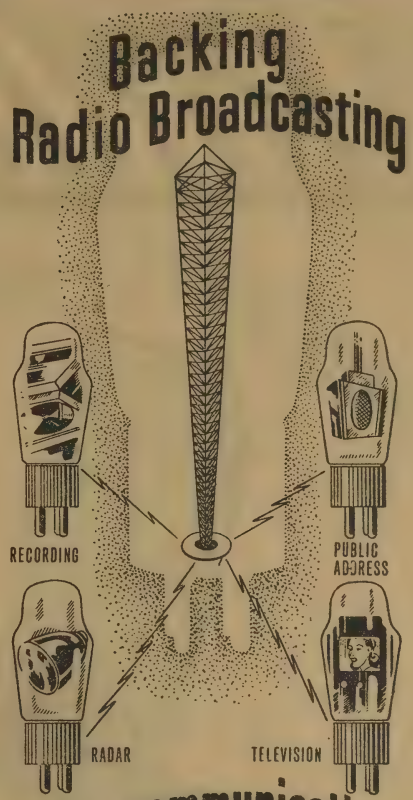

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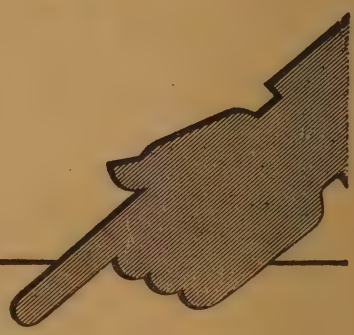

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By C. R. LESLIE, late Technical Officer, Royal Aircraft Establishment

PART IV
RECEIVER ALIGNMENT

The re-alignment of a receiver, after the remedying of faults, is the last "scientific" performance to be done before returning it to its owner "as good as new." On it depends the efficiency of operation, and by it will your worth be chiefly judged—and—as time is NOT on our side we must devise a quick and precise system that will suit our particular circumstances and equipment. It is as well to be familiar with various methods as the actual one used may depend on the particular set under service as speed is closely related to convenience.

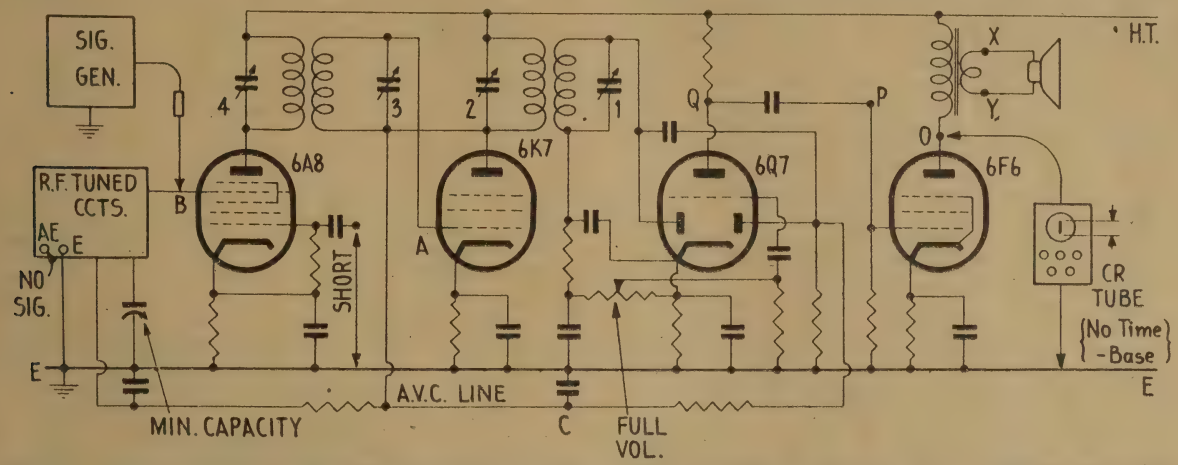


Fig. 1. This schematic shows what should be done to the receiver to place it in the proper operating condition for I.F. alignment. Alternative output meter connections are across XY and across the speaker transformer primary. At the point C, the A.V.C. line should be broken, and the return lead from the tubes earthed.

As the principles involved are the same for both straight and super-het. types we can consider them together—the latter really comprising two straight circuits linked by a frequency changer. The I.F. section is associated with this link, and from a practical point of view must receive primary attention. The whole process then follows definite steps: first the I.F. stage or stages, then the frequency changer oscillator followed by the R.F. stages and aerial input.

DETERMINATION OF THE TRUE I.F. VALUE

The average domestic set has one I.F. amplifier stage and one converter stage, and these two must be harmonised at the correct I.F. for which the receiver was designed. Very few makes have this value indicated on the chassis and unless one possesses the official servicing data, or knows the intermediate frequency from experience, the first problem is to ascertain what the true value really is. Early models often employed a low value round about 110 kc/sec., but this has been largely superseded by the more familiar 460 kc/sec. range because of the reduction of second channel interference, especially on the S.W. bands, by the use of the higher frequency. But values in both bands vary quite considerably as will be appreciated from the following list:—100, 110, 115, 125, 130, 132, 170, 175, 177.5, 180, 181.5, 250, 260, 262, 262.5, 264, 265, 350, 370, 385, 432, 445, 450, 455, 456, 460, 465, 470, 472.5, 480, 485, 490 kc/sec. We do not claim that this list is complete, but it does serve to show what one may be up against. As the oscillator coil is specially designed for a particular I.F. value, it is of the utmost importance to find out what this value is or accurate tracking will be impossible.

If the receiver is fitted with a S.W. band we can make use of the "image frequency"; that is, tune the set to a convenient frequency, say 15 mc/sec., connect the signal generator across the signal-grid circuit of the frequency changer, with the S.W. dummy aerial in the output lead (or a resistance of about 500 ohms) and adjust the signal to the set tuning by working up slowly from a lower value, say, 8 mc/sec. When full response is obtained, either aurally or by an indicating meter, continue slowly past the frequency until the signal is heard again. This second signal is the image frequency. Read the value of this second frequency as accurately as possible and divide the difference between this and the receiver frequency by 2. Suppose the set frequency is 15 mc/sec. and the image frequency occurs at 15,920 kc/sec., then the I.F. to which the receiver IS TUNED is $(15{,}920 - 15{,}000)/2 = 460$ kc/sec. What we shall probably obtain in practice will not be an exact figure of this nature, but a figure equivalent to the order of the I.F., as the transformers will probably be, at least slightly, out of adjustment, and, if they are not harmonised we shall get more than one image fre-

quency at close points and of lesser intensity—these must be sorted out to obtain the true image value. It must be stressed that the value we obtain is the actual I.F. to which the set is TUNED which MAY NOT BE the true I.F. to which the set is DESIGNED.

A similar result can be obtained by another method for any receiver, all-wave or broadcast. In this instance we make use of harmonics. The receiver is put into a sensitive operating condition, i.e., minimum gang capacity, full volume and no signal, and then a modulated signal from the generator is fed into the second or last I.F. stage (or into the signal-grid circuit of the frequency changer) while the local oscillator is shorted out to prevent the generation of harmonics from this source. The S.W. dummy aerial is replaced by a B.C. dummy aerial or a condenser of .0002 mfd. The frequency of the generator is varied slowly and carefully between 500 and 100 kc/sec., starting at the former, and gradually reducing the frequency until the signal response is obtained. This signal may be the I.F. or it may be a harmonic of it. Adjust the generator to TWICE this frequency—if no signal response is obtained, then the previous setting was the actual I.F. As a further check adjust the generator to HALF the original frequency, when a fainter signal response should be obtained of the second harmonic. The reading obtained will usually be only an approximate one and we must now see how we may deduce the designed value from it. If it is suspected that the I.F. stages are much out of alignment with each other it is better to inject the signal into the last stage; otherwise the signal-grid is a good point because of the additional amplification.

If we obtained a single peaked response then we select the nearest standard I.F. value to it, supposing our result was 459 kc/sec., the two nearest are 456 and 460 kc/sec., and we should assume the latter value. If we obtained two adjacent peaks, such as 457 and 459, we inject an average value, i.e., 458 kc/sec., and if the trimmers have to be tightened down for maximum response then the higher value is the more correct and 460 kc/sec. will be the answer. An aural check is quite sufficient for this purpose and only a slight turn of the trimmer screw will indicate whether more or less capacity will be required for maximum response.

Another method of differentiating between actual and designed values is to tune the set to some middle point such as 1000 kc/sec., remove the short from the oscillator and adjust the trimmer and padder for maximum response. If the I.F. we have deduced is HIGHER than the design value it will be found that if we tune to a lower frequency, say 700 or 800 kc/sec., and inject this signal then we shall require to INCREASE THE CAPACITY for maximum response and vice versa. On finding this state of affairs we must try another standard frequency and check again. This is most likely to apply in cases where the I.F.'s are of near value—supposing we estimated 470 kc/sec., but the true value was 472.5 kc/sec., or with estimation at 455 kc/sec. and true value at 456 kc/sec. Where reasonable differences occur such as at 445, 450 and 455 kc/sec., we should probably be able to hit on the right value by the earlier harmonic method.

I.F. ALIGNMENT

We have two main types of I.F. transformers to [illegible] for, namely, the "peaked" type and the "flat top" type. We will discuss the former first as it is the simplest and in quite general use, and then deal with the variation of method for the latter. The first point is to consider what system we shall use for response indication. We can use a milliammeter in the cathode circuit of the last I.F. valve, or voltmeter across it, or we can use some form of output indicator in the speaker section. For this latter we may use our test meter, an A.C. valve voltmeter, oscilloscope or commercial output meter. The test meter can be connected across the speech coil of the loudspeaker on a low A.C. volt range, if such is provided, or we can connect it across the output of the last valve as shown in Fig. 2. The meter should

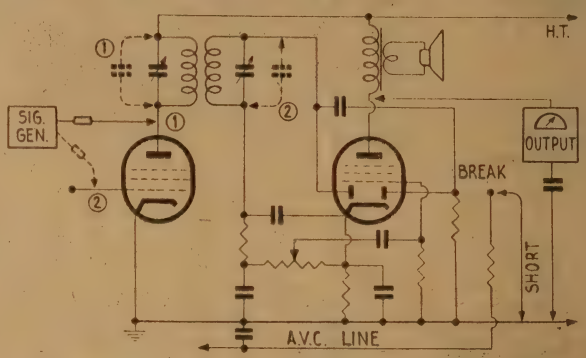


Fig. 2. This schematic illustrates the procedure of aligning "flat top" I.F. transformers by detuning the windings alternatively. Some of the arrangements shown are alternatives to those given in Fig. 1.

be switched to about the 125-volt range, or lower, so that the needle deflection is at about mid scale. The connections for the A.C. voltmeter and oscilloscope are similar except that the V.T.V.M. will not require a series condenser, while the oscilloscope can have the Y deflection plate connected directly through a condenser or through the Y plate amplifier. No time base need be used, as we are only dealing with amplitude comparisons, and a single vertical line is easier to estimate. An output meter would be connected in accordance with the instructions for the particular make.

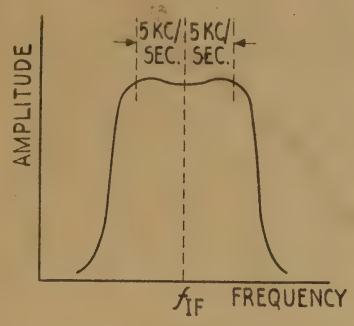
The full procedure is to select and connect the indicator system, place the receiver in its most sensitive condition, inject the correct modulated I.F. signal into the grid circuit of the last I.F. valve, short-circuit the receiver oscillator, and adjust the generator output till the indicator shows a satisfactory reading. Now gradually adjust the secondary trimmer (whether it is a condenser or an iron core) for maximum response—reducing the generator output as the response reading becomes excessive. Then adjust the primary trimmer. As there is interaction between the two, it will be necessary to adjust the secondary again, and then the primary and so on until an optimum setting for each is obtained. Now move the signal generator to the grid of the previous stage and adjust the trimmers similarly—continue in a similar manner for other I.F. stages until the signal-grid of the frequency changer is reached, as shown in the skeleton diagram of Fig. 1, which also indicates various output indicator connections.

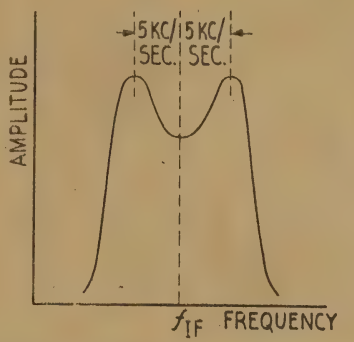
This is all that need be done for the simple peaked type of I.F., though it is always advisable, after the complete alignment of the receiver, to test the I.F.

trimmer settings for QUALITY of reproduction by ear, as it may be found that slight additional adjustments will make an improvement in this respect by flattening the response curve top. Check for both music and speech programmes—a piano or violin recital will be found to be probably the most suitable for the music check.

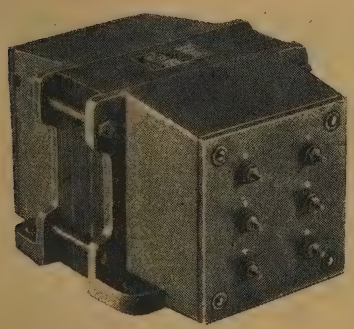
As regards the flat top I.F. type (usually found in high-fidelity sets) the best and readiest method is by the use of a frequency modulated signal generator and oscilloscope. The frequency modulation should be adjustable to ± 20 kc/sec. of the I.F. value. The preferred type of modulation is electronic as this will give the same deviation for any frequency. The modulation is usually at 25 or 50 c/sec. (taken from the mains frequency) and the time base of the oscilloscope is run at the same frequency, so that the picture on the screen is the amplitude/frequency characteristic, which, in the near ideal is shaped with almost vertical sides and a top comprising two low bumps with a slight depression between them, the width of the bumps being the sum of their frequency deviations each side of the rated I.F. as shown in Fig. 3. The oscilloscope Y amplifier may be conveniently connected across the volume control or across the grid circuit of the following audio valve. The effect of any I.F. trimmer adjustment will be immediately visible on the oscilloscope screen, so that it is a simple matter to adjust for optimum amplitude compatible with flatness of top.

The procedure is as follows: Connect up the oscilloscope as mentioned, and inject the correct amplitude-modulated I.F. signal into the grid circuit





Figs. 3 and 4. Fig. 3 (top) shows the appearance on the 'scope screen of a correctly aligned flat-topped I.F. stage. Fig. 4 shows the alignment carried out in such a way that too deep a valley occurs at the centre alignment frequency.



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of the last I.F. valve, but without frequency modulation, and adjust the trimmers for maximum peak on the 'scope screen. Now switch off the amplitude modulation and switch on the frequency modulation, or "wobbulation" as it is sometimes called. Adjust the frequency of the signal generator till the "forward" and "reverse" waves show on the screen and then carefully adjust the generator frequency until the two peaks on the picture coincide, and note the generator output for future reference. The primary and secondary trimmers are now adjusted to give the required response curve as near to that of Fig. 3 as possible. Repeat the performance for the earlier I.F. stages.

If you are not the fortunate possessor of a "wobbulator" unit, another method must be used, but it is a little more complicated and tedious. The same output indication system as before is used, i.e., test meter, etc., but this time we take each winding by itself by detuning the other. First we trim the secondary winding of the last I.F. transformer by connecting a .001 mfd. condenser across the primary (thus hopelessly detuning it) and adjust the modulated I.F. signal plus half the required top width, say 5 kc/sec., at the ANODE of the valve with "brute force" output. The signal will force its way through the detuned primary to the secondary which can then be trimmed exactly for maximum responses. Now transfer the .001 mfd. condenser to the secondary and inject a powerful I.F. minus 5 kc/sec. signal to the grid circuit of the valve—the strength of the input will force its way through the detuned secondary to the detector, and so the primary trimmer may be adjusted in a similar manner. We have now two peaks with a big depression between them as shown in Fig. 4 which is obviously not a desirable one. Remove the detuning condenser, reduce the generator output and adjust its frequency to the rated I.F. centre frequency of the I.F. Note the output reading carefully; take the average of this and the output reading at the response peaks; increase the generator frequency by 5 kc/sec. and detune the secondary trimmer till the output corresponds with the average, reduce the generator frequency to the I.F. minus 5 kc/sec. and adjust the primary trimmer in a similar manner. Now check on the steadiness of the output reading while the generator is slowly moved over a band width of $\pm$ 5 kc/sec. of the rated I.F. We have now, in effect, duplicated the oscilloscope method of flat top trimming, but not in quite such a sensitive manner. The same procedure is then followed with the preceding I.F. stages.

It is sometimes suggested that the "magic eye" may be used as a response indicator; we do not recommend its use, for two reasons—the visual indication is not very sensitive, and the "eye" circuit may be defective, though it may be used as a rough check on the trimming if the "eye" and its circuit are in order.

Where the input signal is going to be of such strength that the A.V.C. system will be brought into action, it is necessary to make it inoperative. The method of doing so will depend on the actual circuit, but in principle the steps taken should ensure that the audio amplification is not affected, and that the A.V.C. line is properly earthed. This can often be done by unsoldering the A.V.C. line at a suitable point before the first controlled valve, e.g., the last I.F. valve, and connecting it to earth or chassis.

(To be continued.)

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A Practical Beginners' Course

PART 10

Last month we dealt with the units of voltage, current, and resistance, described resistors and their circuit symbol, and wound up with something to say on the subject of series and parallel circuits.

Figs. 10 and 11, reproduced here, give typical examples of these two fundamental or basic types of circuit. In the right-hand portion of Fig. 10 we have two resistors, R_1 and R_2, and a coil "B" connected in series. In Fig. 11 we have the resistors and the cell all connected in parallel. It should be pointed out that any components at all may be connected in these two ways, and any number of them. For instance, we could have a circuit in which two con-

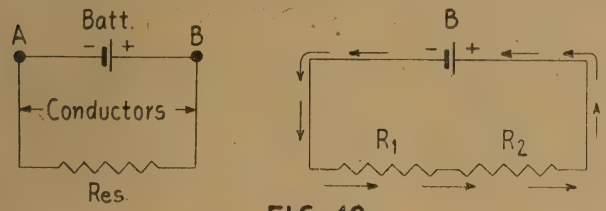

FIG. 10

densers are connected in parallel with a generator. This would be exactly the arrangement drawn in Fig. 11, except that the resistor symbols would be replaced by condenser symbols, and that of the cell by the symbol for a generator. In addition, any number of components may be connected in parallel. The important part is that we have a **parallel** circuit. The same remarks go for the series circuit, for here, too, any number of components may be connected in series, that is, end to end, like the links of a chain.

SERIES-PARALLEL CONNECTIONS

Very few circuits are simple parallel or series circuits. Most are a combination of both, which is called a series-parallel circuit. This is illustrated with resistors in Fig. 13. Here we have two branches connected to the cell, so that we have a parallel circuit. At the same time we have R_1 and R_2 in series. Similarly, R_3 and R_4 are in series. Here, then, is the meaning of the term series-parallel. It is a combination of series and parallel connections occurring in the same circuit. As a further illustration we have reprinted Fig. 2, the earliest of our crystal set circuits. You will remember how in Part 2 of this series we had to go to some length to describe how the components of Fig. 2 were connected together by the wiring. Had we explained at that time the meaning of the terms series and parallel, it would only have taken a few words. For example, Fig. 2 consists of the coil and condenser in parallel with each other. At the same time the crystal and the headphones are in series, and the combination of these two components in parallel with the coil and condenser. You can now see that this brief description is able to describe the circuit well enough for it to be connected up, even without the aid of a circuit diagram.

Thus, the learning of special terms such as the ones we have been discussing enables us to do without a great deal of lengthy description, much as does a circuit diagram. These terms form part of a kind of shorthand which enables a complicated circuit to be discussed much more easily, and an understanding of them is essential if we are to go on to study valve circuits.

KINDS OF GENERATORS

It will be remembered that earlier we had a few words to say on the subject of ways of generating electricity. In particular, we described in very simple terms how each cell of a battery builds up an electrical pressure at its terminals, and that if a conductor is made to connect the terminals together, a current of electrons will flow in that conductor.

We also stated that "generators, dynamos, and

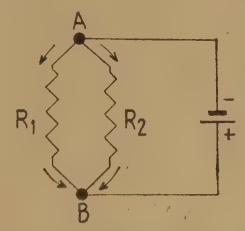

FIG. 11

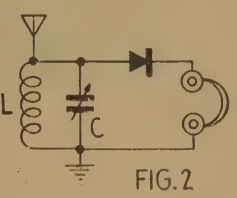

FIG. 2

all machines which generate an electric current by being rotated mechanically depend for their success on the fact that electrons are affected in their movements by the action of a magnet." Apart from this, we cannot here enlarge upon the magnetic effects of an electric current, since to do so would be outside the scope of this course, but it should be remembered that rotating generators are the most important means of producing electricity in large quantities.

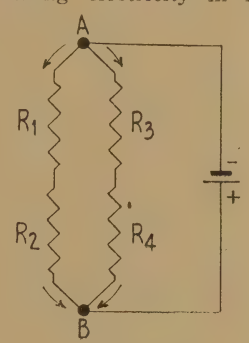

FIG. 13

(It is the lack of water to drive these same generators which is causing us all the present bother in connection with power shortages.) However, there are several other ways in which electric currents may be generated, some of which are made use of in radio work. There are, for example, photo-electric generators. These are so named because they depend for their success on the action of light. When light falls on a plate which has been prepared by depositing on it a thin film of a semi-metallic substance called selenium, the plate and the selenium film each form one terminal of a cell which will generate a small amount of current. This is the principle on

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0-75 mv.	0-1	0-10
0-10	0-10	0-50
0-50	0-100	0-100
0-100	0-500	0-500
0-500		0-1000
0-1000		

RESISTANCE: 0-1,000 ohms.
0-100,000 ohms.
0-1 megohm (with external battery).

1,000 ohms per volt on all voltage ranges. ACCURACY 2 %

Dimensions: 5¾ in. high by 4⅛ in. wide by 3 in. deep.
Weight: 2 lb. (including internal battery).

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Covering 100 kc/s. to 30 mc/s.

A mains-operated precision all-wave Signal Generator for the accurate alignment and testing of all types of Radio Receivers.

Contained in a copper-sprayed steel cabinet finished in black ripple lacquer. The front panel consists of anodised aluminium, which ensures a permanent finish to the instrument.

The six Frequency Ranges are clearly marked on a 6 in. diameter illuminated scale which is visible through a glass disc fitted in the front of the panel.

A special feature of the instrument consists in the double screening, which has been carefully carried through, this resulting in an outstandingly low level of stray radiation. As the instrument also provides an adjustable audio frequency voltage, it lends itself for testing public address equipment and the output stages of radio receivers.

Frequency Ranges: 100 to 250; 250 to 650; 650 to 1600 kc/s. 1.6 to 4.5; 4.5 to 12; 12 to 30 mc/s. Accuracy of Calibration, 1%

R.F. Output Voltage: Maximum output voltage on all ranges 1 volt into 10 ohms. An uncalibrated attenuator is provided consisting of a variable control and a 6-step multiplier. The output terminates in a co-axial screw connector.

MODULATION: All ranges are modulated to a depth of 30% by an internal 400-cycles oscillator. This may be switched off to provide an unmodulated signal. The 400-cycles voltage is brought out to a pair of terminals through a separate attenuator.

MAINS VOLTAGE: 200 to 250 volts A.C. or 105 to 115 volts A.C. 50/60 Cycles.

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The LAMPHOUSE

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which the photo-electric light-meters that are used for photography operate. The amount of current generated by a selenium cell in this way is very minute indeed; in fact, only enough to operate a very sensitive electric meter. The photo-electric effect, however, is a very important one in many applications of radio and electronics. The photo-electric cells used in talking-pictures and burglar-alarms, etc., depend for their action on a different photo-electric principle, for they are not true generators of electric current at all, but the selenium cell is as much a generator of electricity as is an ordinary "dry" cell used in a torch battery.

Another important effect which enables us to generate electricity in yet another way is the **thermo-electric** effect. This name indicates that the effect establishes a connection between **heat** and electricity.

Suppose we take a thin strip of iron and a similar strip made of some other metal such as copper. If we join one end of the iron strip to one end of the copper strip, say, by soldering them together, the simple affair so constructed becomes a generator of electricity, provided that the place where the metals are joined is either warmer or colder than the remainder of the composite strip. The free ends of the strip we have made can be regarded as the terminals of a thermo-electric generator, for if they are connected by a conductor, and either heat or cold is applied at the join in the strip, an electric current will flow in the circuit thus provided. The only difference made by the fact of the join being warmer or colder than the remainder of the strip is to the direction in which the resulting current flows. This thermo-electric effect is used in several ways. It is not used to generate large quantities of electricity, since it is not capable of doing so, but it is very valuable as a means of making various measurements. For instance, the hotter the join in the dissimilar metals, the more current will flow. As a result of this fact, a combination consisting of a **thermocouple** (as the strip is called) and an electric meter, to measure the current produced, may be used to measure very high temperatures, such as those inside furnaces of one sort or another. Again, electric meters are made with a small thermocouple inside the case. These are the most accurate kind known for measuring currents at very high frequencies—such as the ones which when radiated into space become radio signals.

It is interesting, too, to note that an instrument based on the thermo-electric effect, the thermopile, has been made so sensiive that it can record or measure the amount of heat that would be received from a lighted candle at a distance of a mile!

We have enlarged to some extent on the thermo-electric effect because it is closely allied to the **thermionic effect** which makes valves possible.

THE THERMIONIC EFFECT

Strictly speaking, this does not give us a method of **generating** electricity, for reasons which will appear later. The name is derived from **therm**, a Greek root meaning heat, and **ion**, another Greek derivation that is used in chemistry and physics to mean an atom or molecule which has lost one or more electrons. Thus the name of the effect goes quite a long way towards telling us what it is.

Although it cannot be seen happening, even with the most powerful microscope, scientists know that the atoms and molecules which go to make up all matter are in a constant state of movement or agitation. It is known further that the higher the temperature of a piece of matter, the faster are its atoms or molecules moving. This **thermal agitation**, as it is called, does not represent a movement in any particular direction, but simply a kind of vibration about an **average** position, which usually stays fixed. The reason the atoms behave in this manner is that they are held together by a force which is nothing more than the force of gravity, so that, although higher temperatures cause them to vibrate more rapidly, they are still held in place by the gravitational forces between them. However, if the temperature of a substance is raised high enough, some of the atoms vibrate so quickly that they escape from the gravitational forces holding them to the main body of the material and fly off into space. This process is really that of evaporation and occurs in liquids very quickly when they are heated above a certain temperature.

The subject of evaporation has been mentioned because it is really the very same process as the thermionic effect, with only one difference—the thermionic effect consists of the evaporation of **electrons** from substances.

You will remember that an electric current is able to flow along a wire because some of the outer electrons in the atoms at the surface of the metal are quite loosely held, and are, in fact, constantly being interchanged by the various atoms. Now, if metals are heated to a high enough temperature, they melt and then evaporate, just as water does, because whole atoms are escaping from the mass of the metal. Other metals, which have a very high melting-point, do not lose whole atoms when their temperature is raised, but only electrons. In other words, the electrons evaporate from the surface of the metal. Now, this evaporation of electrons is the thermionic effect.

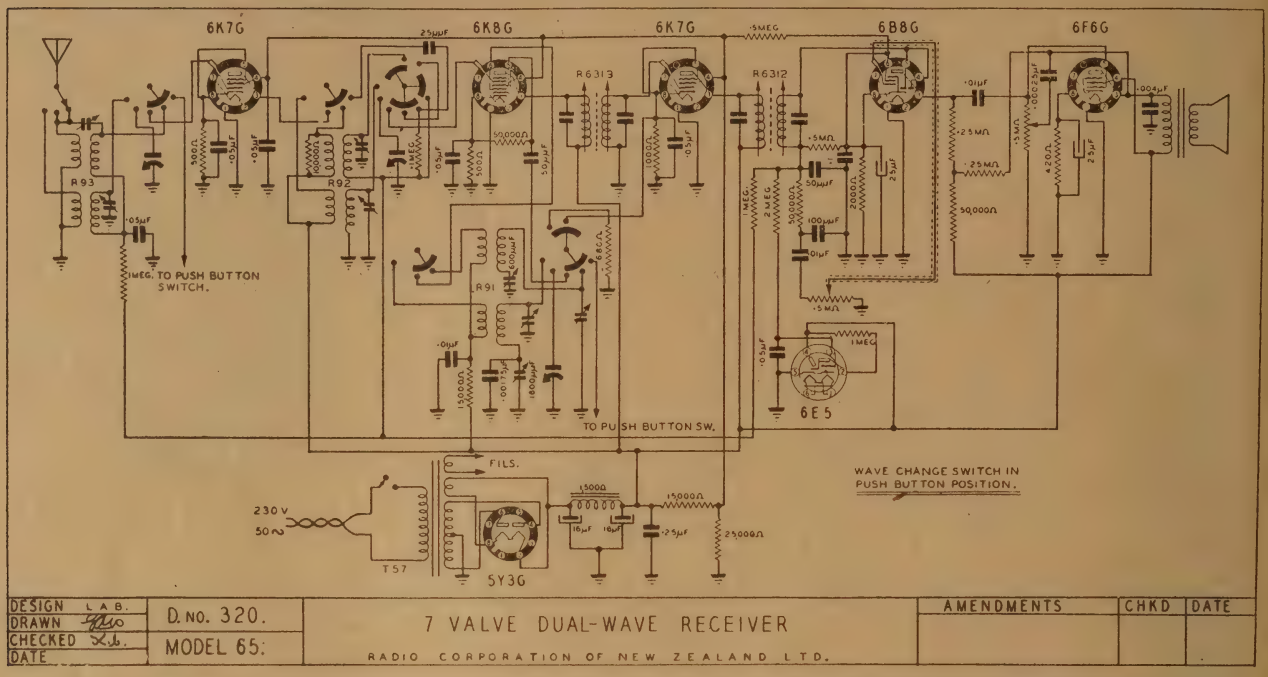
We can see that if electrons have actually escaped from the surface of a piece of metal, it should be possible to make use of them in some way; but the thermionic effect does not make a hot piece of metal into a generator of electricity. The question is, what happens to the electrons once they have escaped from the metal? Do they fly off into space and become lost, or do they find their way back to the metal again, or what?

What actually happens (unless we take steps to see that it does not) is that the escaped electrons do not get very far. Having escaped, they are strongly attracted by the metal from which they came, so that they actually form an invisible "cloud" of electrons all round the surface of the hot piece of metal. If the temperature is lowered again, the electrons fall back into the metal, which now has just as many electrons as before. However, by taking certain precautions and heating the piece of metal in a special way, it **is** possible to make use of these electrons freed from their atoms by the thermionic effect. When we take these precautions, and heat our metal in the right "special way," we have the simplest kind of valve used in radio—the **diode.** This will form the subject of our next month's instalment.

(To be continued.)

FOR THE SERVICEMAN

COLUMBUS MODEL 65.—This and the following circuit, Model 60, require no special alignment instructions, except to note that the I.F.'s are both 464 kc/sec.

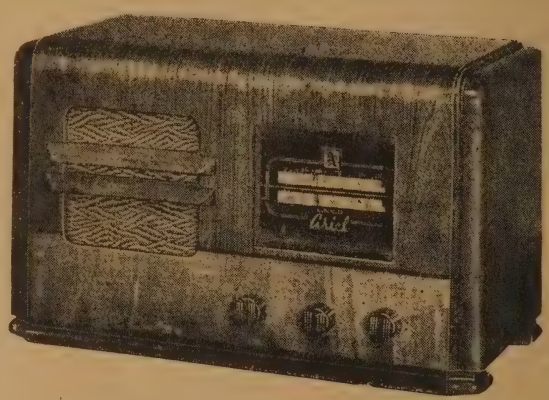


DESIGN L.A.B. DRAWN CHECKED DATE	D. NO. 320. MODEL 65.	7 VALVE DUAL-WAVE RECEIVER RADIO CORPORATION OF NEW ZEALAND LTD.	AMENDMENTS	CHKD / DATE

OUTSTANDING RADIO BARGAINS

The illustration shows the attractively-finished Radio which may be made with our 5-valve Broadcast Kit.

The appearance and performance of this Radio, if properly constructed, are at least equal to any manufactured article. Cabinet finished in two-tone walnut veneer will take from 5 in. to 8 in. speaker. **Price of Cabinet, £3/8/-. Kit Set Price, with 5 in. Speaker, £12/10/-. Extra for 8 in. Speaker, 15/-.**



The dial incorporated in this cabinet may be bought as a separate unit for 25/-
Coils to match. Hi-Imp Aerial, 3/6. Oscillator, 3/6.
Loop Aerials: Suitable for midget, mantel and portable radios, **7/6**

Power Transformers
60 Mil. 6.3 5-volt 325 aside, **27/6**
80 Mil. 6.3 5-volt 325 aside, **33/6**

Potentiometers
All sizes, without switch, **4/-**

6 v. Synchronous Vibrators
To fit standard 5-pin socket, **25/-**
Valve Sockets: 4, 5, 6, 7, and 8-pin, **8d. ea.**
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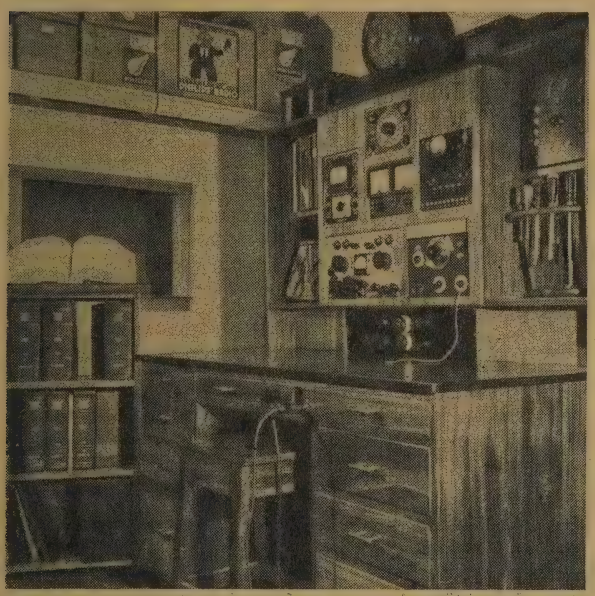
MAKING WORK A PLEASURE

Our photograph this month shows one of the three test benches to be found in the Service Department of M. J. Hillier, Ltd., Studholme Street, Morrinsville. The ideas incorporated in this exceedingly workmanlike set-up are well worth consideration by any serviceman seeking to construct a modern test-room or to modernise an existing one. We are indebted to Mr. Hillier himself for the following description of the equipment and its lay-out.



The general idea behind this particular bench set-up is that the operator can remain seated and have all instrument controls, tools, or other requirements within easy reach.

Comprising two units, the base portion measures 60 in. x 27 in. x 34 in. high, with a three-inch toe recess below the drawers. Despite the added cost, drawers are to be favoured over any form of cupboard arrangement, in that access to the item required is easily gained.

The soldering iron resting on a piece of asbestos plaster-board, in the asbestos-lined recess, is conveniently at hand, and removes the possible damage by heat to anything on the bench. When standing-by, the iron is switched to half-heat.

The valve-tester is housed in the second drawer on the left, while the right-hand one contains all the odds and ends such as wire, spaghetti.

The second unit rises 69 in. from the floor, the depth increasing from seven inches to 12 inches at the level of the bench-top to allow of better distribution of weight of the instruments.

Two revolving stands, one octagonal with sloping sides to support pliers, the second being after the style of a spool to carry screwdrivers and similar tools, are mounted on either side. Quick reference matter, such as valve data, is kept in the upper pigeon-hole.

Grouped on the bench shown here are oscillator, chanalyst, multimeter, condenser tester, and test speaker. There is a patching system on the speaker that provides for any field, any output, or any plug or pin outlet from all makes of sets. This is a great time-saver.

By setting the instruments on shelves held in position with screws, then taking a piece of threeply the overall size of the instrument portion, and cutting out the required size openings in the appropriate positions, any rearrangement or replacement of instruments is catered for. The back to this section, which is arranged to cut off the power supply when removed, is held in place with turnbuttons to facilitate the inspection or removal of a unit. The 6 in. x 24 in. panel set back three inches from the front of the instrument panel and appearing directly below, carries the popular outlets for 110 and 230-volt power supply.

Finish is a matter of taste. We finished ours in natural rimu, which, as far as the instruments are concerned, is very effective.

The remaining unit seen in the photo is a book-case which holds circuit data. The unit is mounted on castors of the dinner-waggon type and is readily moved away from or brought up to either bench as required, with the added advantage that, as the bench is usually fully occupied, one has a place to put the book. Note the top is hinged to tip up.

As each bench is individually equipped, it is readily seen that the operator can proceed at ease and undisturbed.

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WITH RADION P.V.C. INSULATED WIRES AND CABLES

With RADION SUPER QUALITY P.V.C. Insulated Wires and Cables whether your need be for a fine wire for instrument work or for heavy power cables, Radion P.V.C. insulated wires and cables offer you many advantages. The pictures indicate the wide range of applications—from shot-firing wire to lamp cord. In between there is a long list of uses in industrial and domestic construction, communications, manufacturing of all kinds, transportation, public utilities and every other industry in New Zealand. Heading the list of outstanding advantages is the excellent electrical properties offered with P.V.C. insulation. Thin wall construction with high dielectric strength and available in fourteen distinct colours for ease of identification. Following is a long list of normally destructive factors which these new cables will resist: Oils and greases, water, air, ageing, sun, abrasion, flame, chemicals and many others. Radion Super Quality P.V.C. Insulated Wires and Cables offer far far more than similar rubber cables and are everlasting.

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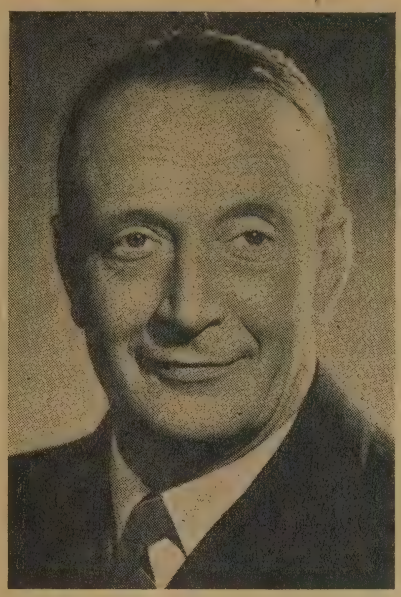
" Founders of the Insulated Wire and Cable Industry in New Zealand "

Mr. Leighton Lord



Mr. A. E. Poll

OUR GOSSIP COLUMN

Philips Electrical Industries of N.Z., Ltd., announces that Mr. A. E. (Ted) Poll, who has been Managing-Director for the last eleven years, will shortly leave for Australia, where he is to take up an important position with Philips Australian Company in Sydney.

Mr. Poll is very well known in the Radio Industry throughout New Zealand, and his departure will be a matter of genuine regret to his many friends here. However, in taking over his new and important post of Chief Commercial Executive in Philips Electrical Industries of Australia Pty., Ltd., he carries with him the good wishes of his associates and colleagues in the Trade.

On the declaration of War, as a Naval Reservist, Lieut. Poll was posted to a destroyer flotilla and then went to the Asdic School at Osprey, in England. From there he saw the best part of three years' service with the destroyers in the grim, icy wastes of the North Atlantic. During part of his War Service he was on loan to the Canadian Naval Authorities and also participated in the operations which led up to the transfer of the 50 Lease-Lend destroyers from the U.S. Navy to the Royal Navy.

After further experiences, Lieut. Poll returned to New Zealand, where, after a short period in the Navy Office in Wellington, he went North, and for nearly a year was with Naval units roaming the wide expanses of the Pacific. Subsequently he returned to New Zealand and took over an administrative post with the Navy Office until he obtained his discharge from further active service, which was about the time of the Armistice.

Being a member of the "silent service," Ted Poll can only be got to speak of his war experiences on rare occasions, but he opened out once to tell us of his first jolt, when, being the sole New Zealander present, he was at the receiving end of a German bombing blitz in the South of England. Night had fallen and every bed in the shore station was occupied when the Air Raid siren sent one and all scurrying for the shelters, and very necessary it was, too. The bombs did considerable damage, and on the All Clear being sounded the personnel dragged their weary bodies back to clear up the mess and find a spot to sleep for the remainder of the night. To their amazement one bed was still occupied and the sleeper unhurt, and on being dragged out of it all they could get out of the sleeper, Ted Poll, was "Get to blazes and let a fellow sleep." Thus he helped to build the New Zealanders' reputation of being "tough," but Ted omitted to tell them that he had slept through it all and never heard the Air Raid siren, the rush for the shelters, the bombardment, or the falling timbers.

Mr. Poll has for a long while been a member of various Radio Committees associated with trade activities, and towards the end of 1946 he was appointed President of the Radio Manufacturers' Federation of New Zealand.

Mrs. Poll will accompany her husband when, towards the end of March, he flies per Tasman Airways, and the good wishes of the Industry will go with them to Australia.

* * *

We take this opportunity of extending a welcome to Mr. Leighton Lord, who arrived in New Zealand at the beginning of March, and who will assume the post of Managing-Director of Philips New Zealand organisation on the departure of Mr. A. E. Poll.

After his discharge from active service at the end of World War I, Mr. Lord went to Australia, where he became a well-known identity in Electrical and Radio circles, having been an executive member of Philips Australian Company since its establishment in 1925. He came to New Zealand for several months in 1927 to establish the Philips New Zealand Company. His association with Philips covers, in all, a period of thirty years, and he brings with him a wealth of experience in electrical and radio merchandising which will be of considerable value in the further development of Philips New Zealand manufacturing activities.

* * *

Mr. Wm. J. Blackwell was born in England, and received technical education there. Technical radio education was completed at the Marconi Schools in Sydney, New South Wales. Mr. Blackwell joined Amalgamated Wireless (A'sia), Ltd., as a marine operator; after a short period at sea, he returned to New Zealand in 1930, and became associated with the Philco distributors, Charles Begg and Co., Ltd.

After the importation of complete radio receivers was prohibited, Mr. Blackwell became General Manager of Dominion Radio and Electrical Corp., Ltd.,

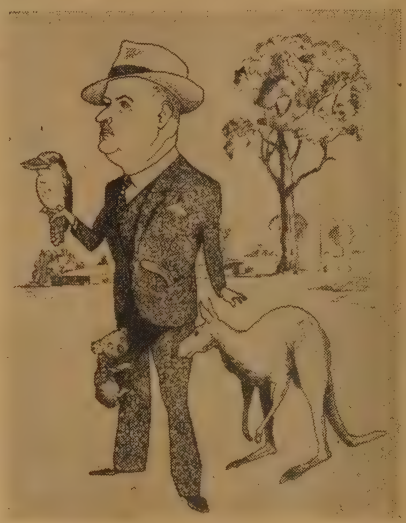
the organisation chosen for the manufacture in New Zealand of Philco, which position he still holds.

Mr. Blackwell became an Associate Member of the Institute of Wireless Technology in 1934, and a Full Member of the British Institution of Radio Engineers in 1943. He recently returned from an extensive visit overseas, where, at the Philco factories in England, America, and Canada, he studied the latest manufacturing techniques in radio receiving sets and electrical appliances. Mr. Blackwell is Immediate Past President of the New Zealand Radio Traders' Federation and is Vice-Chairman of the Auckland Radio Manufacturers' Trade Group. He has a very strong interest in the Radio Trade generally and manufacturing in particular.

* * *

"Brack" Brackenridge, Wingate's man, is responsible for one of the best "flaps" Thames police have had in recent months. Leaving his car outside a Thames store while he went to lunch, he returned to find the car had disappeared. Promptly "Brack" informed the local vice squad. A watch was set on all roads out of Thames, toll calls were put through to country police stations, and all in all a widespread net was set to catch the daring car thieves. Then the car was found—outside a Thames store! "Brack" had merely returned after lunch to the wrong parking place. The question now is, "Where did 'Brack' have lunch?"

* * *



An artist's impression of J. R. Robertson, New Zealand manager and director of International Radio, surrounded by his native flora and fauna—this is how we discovered J.R. is an Australian by birth.

SOLAR CAPACITORS

We are the sole New Zealand factory distributors for capacitors manufactured by the SOLAR MANUFACTURING CORPORATION, New York.
We stand behind all SOLAR products sold by us but cannot accept responsibility for goods of indeterminate age obtained overseas by "back door" methods.
If you are told by any other firm that they are the New Zealand agents for SOLAR, just smile as you would at any other funny story and remember that the sole authorised factory distributor in New Zealand for the Solar Manufacturing Corporation, New York, is

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Telephones 32-160, 32-161, 32-162.	Telephones 43-590, 46-651.	Telephone 36-736.	Telephone 11-531.

DX BROADCAST 12

(Continued from page 28)

audio output so long as the transmitter being received is not overmodulating. A great deal of external noise, both natural and man-made, produces in a receiver audio noise pulses far exceeding in amplitude the audio level given by the carrier when 100 per cent. modulated. Any such pulses will cause the limiter diode to conduct. When this happens, the detector load resistor is short-circuited by the limiter diode, which, when conducting, has a resistance of only a few thousand ohms. Thus for the duration of each high-amplitude pulse there is no audio output from the set. Since the noise pulses are of very short duration, the intelligibility of the signal remains unimpaired, and the noise output is very greatly reduced.

With this circuit the noise is never removed altogether, and it is clear that noises not exceeding the carrier level in amplitude remain unaffected, so that the effect of the limiter is to reduce strong noise impulses to the level of the carrier. It is very effective indeed in increasing the readability of weak signals that tend to be marred by noise which comes in via the aerial or power line.

Unlike most noise limiter circuits, this one has no adjustments apart from the on/off switch, and unless a station is over-modulating will not appreciably affect the quality of the output should it be turned on when the set is tuned to a local station.

A.V.C. AMPLIFIER AND RECTIFIER

The A.V.C. amplifier is V_8, another EF39. Its circuit is quite conventional except for the fact that its input, as previously stated, is resistance-capacity coupled from the secondary of T_6, this connection virtually placing the inputs of V_5 and V_8 in parallel. Contrary to the other I.F. stages, V_8 is working at full gain, so that the output to the A.V.C. rectifier V_8 is greater than that supplied to the second detector by V_5.

The A.V.C. rectifier uses a second 6H6 with its sections in parallel. Its circuit is quite normal, except for the fact of the split load resistor made up by R_{32} and R_{30} in series. Since two A.V.C. voltages are derived from the rectifier, each of these must have its own filter circuit to remove audio voltages from the A.V.C. lines. The voltage delay on the A.V.C. diode is obtained from the divided R_{55} and R_{29}, which places the cathode of V_7 at approximately 10 volts positive. In this way, the carrier level at the plate of V_7 must have a peak amplitude of slightly over 10 volts before the A.V.C. diode starts to conduct, and control the receiver again. The advantage of a high delay voltage is that, once the A.V.C. comes into action, the output level is held much more nearly constant than when a low-delay voltage is used. Also, the receiver is made to produce good A.V.C. action on quite weak signals without affecting the sensitivity for still weaker ones. Where a small or no delay voltage is used, the A.V.C. reduces the sensitivity on weak signals without acting efficiently in holding the output level of the set constant.

SW_2 is the A.V.C. on/off switch. Owing to the two A.V.C. lines, this must be a double-pole-double-throw component. On the off position the returns from the controlled valves to the A.V.C. lines are earthed, leaving the latter still functioning, but "up in the air" doing nothing to the sensitivity of the set.

THE AUDIO STAGES

The audio amplifier is quite conventional, but is capable of excellent quality. Its circuit is almost exactly that of the "4½-watt Gramophone Amplifier" which appeared in these pages a short while ago. The output stage V_{11} is a 6V6, driven by V_{10}, a 6SJ7. An excellent negative feedback circuit is used, incorporating the bass-boosting type of tone control, which in this case has been made slightly more effective by increasing the value of the control resistor R_{51} to 2 megohms. Afurther slight modification to the original circuit has been made by decreasing somewhat the value of the condenser C_{41}. This has the effect of causing the boosting to start at a rather higher frequency, somewhere in the middle range, rather than at the low-frequency end of the audio band. This feature is exceedingly useful in conjunction with the noise limiter in increasing the readability of weak signals under considerable noise.

It was found that the bass and middle boost obtained with this circuit gave a marked increase in readability in such circumstances, whereas a top-cutting control, tried as an alternative, gave no improvement whatever. This is understandable in view of the very high selectivity of the receiver, which causes the high-frequency response to be strongly attenuated in any case. Further top-cutting therefore decreases intelligibility rather than increasing it.

Film Industries Ltd. of London, proudly introduce

THE LS7 P.M. MOVING COIL LOUDSPEAKER UNIT AND 40 in. ALL-METAL HORN !

Designed for high-power Public Address work and factory use such as staff location and "Music While You Work."

Features:

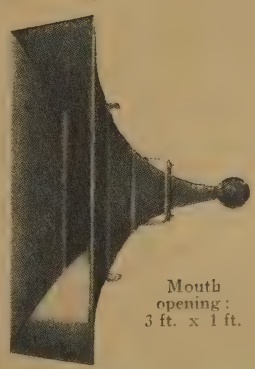
Highly Directional.
High Electric—acoustic efficiency.

Carefully planned Frequency response.

Weatherproof.

Watts handling capacity—12.
Coil impedance—10 ohms at 400 c.p.s.

Average impedance—50-10,000 c.p.s. on 40 in. horn—12.0 ohms.



Mouth opening: 3 ft. x 1 ft.

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Telegrams: ELECTRONIC

POWER SUPPLY

The power supply circuit is quite normal and requires no comment apart from the rating of the transformer. In the original model an 80 ma. transformer was used. At first sight this might seem to be overrun by the large number of tubes that have to be supplied. In practice this is not the case, since the three controlled stages draw less than half their normal space current, owing to the fact that they are biased well back. Add to this the fact that the infinite impedance mixer draws practically no plate current and that the B.F.O. tube draws very little, and it becomes apparent that, even at full gain, the receiver is drawing very little in excess of 80 ma. total plate current, and even less when it is tuned to a signal any greater than about ten microvolts.

THE B.F.O. CIRCUIT

This requires little comment, as it has been seen before in these pages. The tube, however, is a 6N7, not, as stated last month, a 6SN7. In addition, the grid shown on the diagram as unconnected should be earthed. A variation has been introduced here in that the output is taken from the cathode instead of from the plate. This connection is preferable, since the aplitude is lower at the cathode, and no detuning of the oscillator coil L_2 occurs due to the connection. The unmarked condenser across L_2 represents the trimmer associated with it in the I.F. transformer from which the B.F.O. coil is made. C_{32} is the B.F.O. pitch control which appears on the front panel, and SW_3 is the on/off switch.

(To be concluded.)

MINIATURE COMPONENTS

(Continued from page 6)

give the low contact resistance of one-hundredth of an ohm with a current-carrying capacity of 50mA. The difficulty was overcome by making the contact springs from phosphor bronze strip on which pure silver one-thousandth of an inch thick was rolled. The switch is provided with 12 contacts, and is available as single, two, three, and four-pole.

Miniature two-gang and three-gang tuning capacitors, with an overall depth behind the panel of 1.87 in. and 2.67 in. respectively, were also produced for the forces and will be available for general use very shortly.

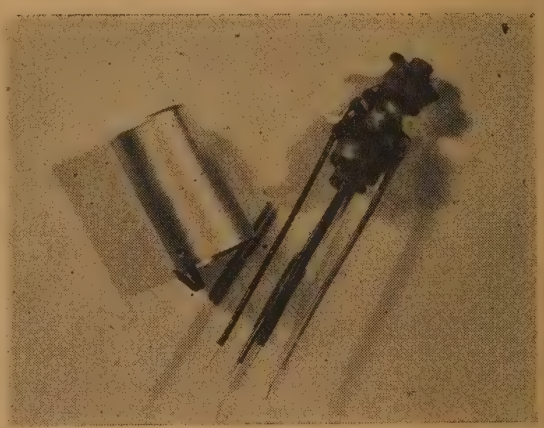
Other components and accessories which have been greatly reduced in size during the past year or two are: Composition fixed resistors—now little thicker than a pencil lead, selenium rectifiers, and H.T. batteries.

As a result of all the research, both in Britain's radio industry and in Government laboratories, which went on throughout World War II and is still being actively continued, into the problem of reducing the dimensions of components without adversely affecting their electrical characteristics, manufacturers and amateurs now have an entirely new field of construction open to them. Advantage is already being taken of this, and the first of Britain's personal portables is due off the production lines.

MIDGET I.F. TRANSFORMERS

The new midget I.F. transformers developed by Hohner are by far the smallest manufactured in New Zealand. They measure only 2 in. long by 1⅛ in., and although they are small, the Q is excellent—in fact, very little difference can be found when compared with a standard transformer. The transformers are permeability tuned, and the coils are wound on polystyrene former.

The Hohner midget I.F. transformers are admirably suited for portable and small radios.



Price 14/8 each

Supplies available from:—

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MULTI-CORE SOLDER

The Finest Cored Solder in the World

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TRADE NEWS

Mr. John R. Robertson, Director and Manager of International Radio Co., Ltd., Auckland, New Zealand Industries Ltd., New Zealand Wires and Cables Ltd., and Bobbie Pins Ltd., is at the moment very busy installing plant for the drawing of copper wire here in New Zealand. This will be the first plant of its type in New Zealand, and will probably be the latest, fastest and most up-to-date plant in the Southern Hemisphere. This plant will draw wire from ¼ in. rod dawn to 40 gauge and will have sufficient capacity to handle New Zealand's entire requirements for copper wire. Stranding and bunching machines are also being installed which will handle any stranding or bunching of copper wire necessary in New Zealand. This plant will be commencing operation approximately 1st May.

'PEERLESS' PORTABLES

have, by their superior appearance and performance, been accepted as New Zealand's most popular portable radio.

SPECIFICATIONS:

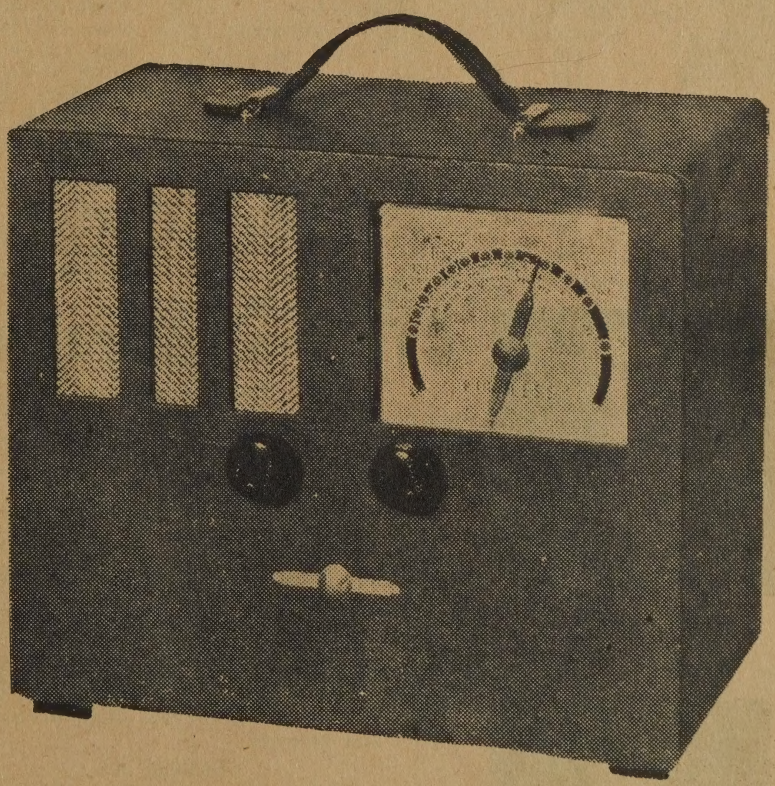
5 VALVES: Two 1N5GT, one 1A7GT, one 1H5GT, one 1Q5GT.

BATTERIES:
The new light-weight Eveready Mini-Max. Two 45v. "B" batteries No. 482, one 1.5v. "A" battery No. 745. Total weight of batteries, 6lb. 9ozs. Approximate life of batteries, 240 hours.

SPEAKER:
5 in. permanent magnet.

CABINET:
Length 12 in., height 10½ in., depth 6⅝ in. Covered with genuine "Rexine" cloth. Total weight with batteries, 16½lb.

AERIAL:
Loop aerial is built into the cabinet and provision made for connecting an external aerial.



Appointments of dealers have not yet been completed in some territories. For further information and franchise, write to the manufacturers:

MEGANN LIMITED, 60 Victoria Street, WELLINGTON

G.P.O. Box 12 - Phone 45-863 - Telegrams "Pialba"

A REGULATED POWER SUPPLY

(Continued from page 13)

the D.C. output voltage by the 2A3 filament supply. If this hum is too great to be tolerated, it can easily be removed by placing a centre-tapped resistor of 25 or 50 ohms across the filament circuit of the 2A3's, and taking to the centre-tap all connections which we have drawn as connected to the lower side of the 2A3 filament circuit. This will effectively remove this source of hum, and the result is an exceptionally hum-free supply.

PERFORMANCE

In common with all regulators of this type, the amount of output current that can be drawn before the regulation starts to deteriorate decreases at the higher output voltages. This is because when the plate current of V_3 has reached cut-off, further regulation cannot take place.

Tables are given here which show in some measure the performance of the prototype with one, two, three, and four 2A3's used in the V_4 position. The currents specified are the maximum figures which may be drawn at the given output voltages for a drop in output of 2 per cent. in voltage.

One 2A3		Two 2A3's	
Volts.	Milliamps.	Volts.	Milliamps.
250	140	250	185
300	110	300	140
350	75	350	85
400	55	400	60
Three 2A3's		**Four 2A3's**	
Volts.	Milliamps.	Volts.	Milliamps.
250	200*	250	200*
300	150	300	165
350	90	350	100
400	80	400	90

*Maximum rating of power transformer; test not carried further.

It should be realised that the quoted figure of 2 per cent. is not nearly as good as what will be obtained in actual practice. The above tests were carried out by setting the voltage at no load, and then applying an increasing load until the specified percentage drop occurred. This is equivalent to saying that if the supply were used to power a device which drew a variable current ranging from zero to 200 ma., at 250 volts, the regulation would be 2 per cent. This is really an absurd condition, which would hardly be met in any actual equipment working from 250 volts. The point is that any device drawing a current that varies by even 50 per cent. would be supplied with a voltage regulated to very much better than 2 per cent.

Where the current drain varies only slightly, the regulation of this power supply can be considered perfect, within its rated capabilities.

CLASSIFIED ADVERTISEMENTS

TEST EQUIPMENT FOR SALE: Calstan Type 222 Valve Checker—tests all American types, also Philips P Base and English Valves. A really good buy at £9/10/-. Calstan 445 Analyser and Multi Range A.C./D.C. fan type meter in good order—£7/10/-. Triplett Dynamic Valve Tester and A.C./D.C. multi range meter and condenser tester model 1503 in excellent order. An outstanding offer at £20. One consolidated all purpose Condenser Analyser £6/15/- and a Triplett 1200-volt ohmmeter (the latter requires two new shunts) but good buying at £6. Further information from Box 21, Carterton.

FOR SALE: 3 in. six-tube oscilloscope in factory cabinet as new £25. Write: Tidswell, Main Street, Dannevirke.

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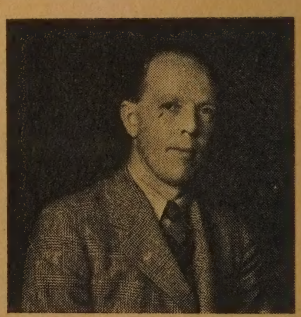
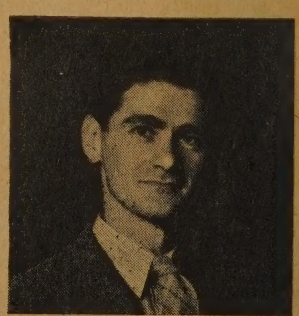
TURNER Microphones.
ALTEC LANSING Duplex Speakers, etc. etc.
JACKSON TEST EQUIPMENT.

Inquiries invited. Tell us what you require. Agencies available in certain districts.



A. M. (Don) Cooper (Design Engineer)

W. (Tubby) Mahood (Technical)



D. (Dan) Coronno (Installations and Service)

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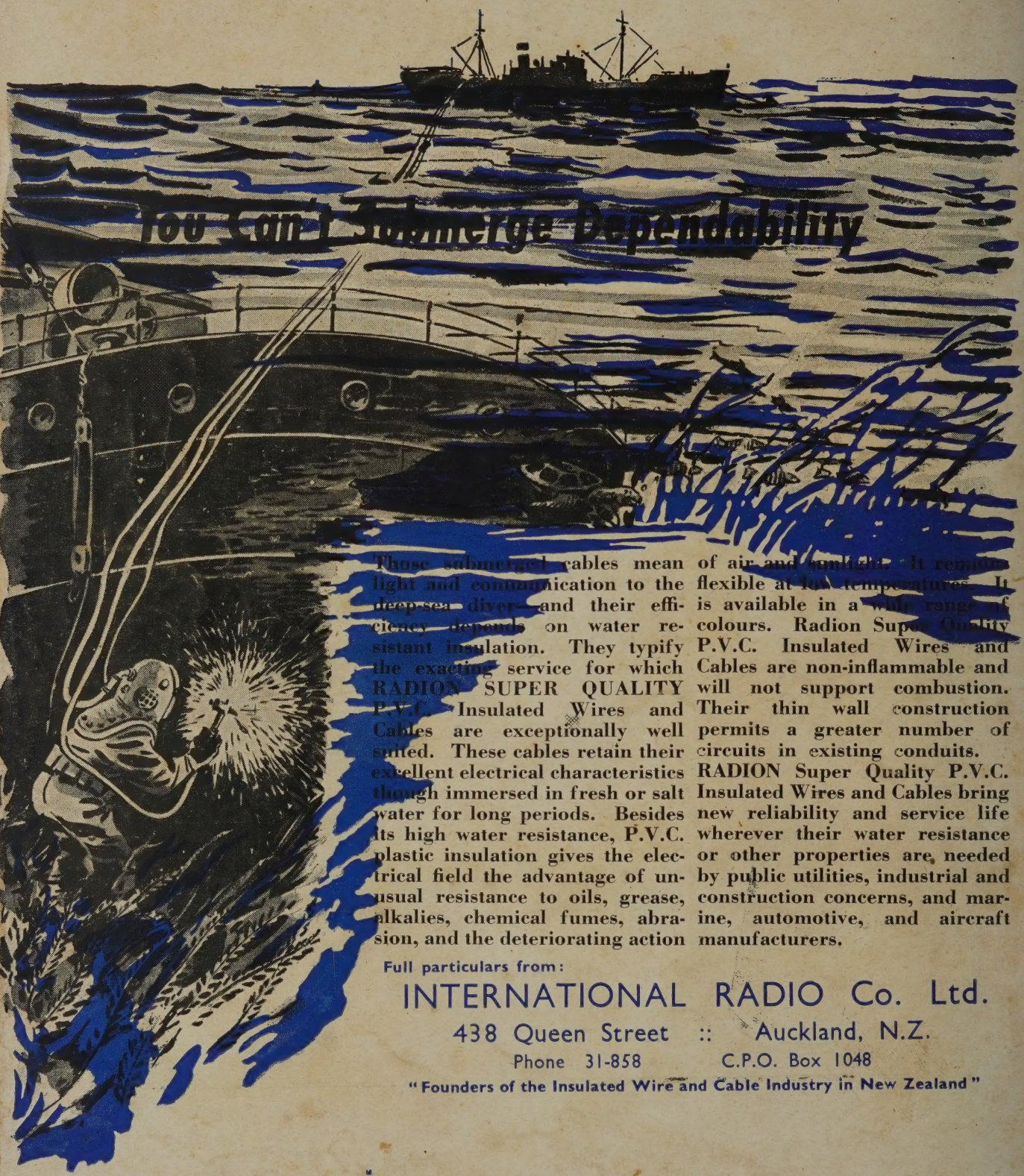
ER47/T65

RADION SUPER QUALITY P.V.C. Insulated Wires & Cables



Those submerged cables mean light and communication to the deep-sea diver—and their efficiency depends on water resistant insulation. They typify the exacting service for which RADION SUPER QUALITY P.V.C. Insulated Wires and Cables are exceptionally well suited. These cables retain their excellent electrical characteristics though immersed in fresh or salt water for long periods. Besides its high water resistance, P.V.C. plastic insulation gives the electrical field the advantage of unusual resistance to oils, grease, alkalies, chemical fumes, abrasion, and the deteriorating action of air and sunlight. It remains flexible at low temperatures. It is available in a wide range of colours. Radion Super Quality P.V.C. Insulated Wires and Cables are non-inflammable and will not support combustion. Their thin wall construction permits a greater number of circuits in existing conduits. RADION Super Quality P.V.C. Insulated Wires and Cables bring new reliability and service life wherever their water resistance or other properties are needed by public utilities, industrial and construction concerns, and marine, automotive, and aircraft manufacturers.

Full particulars from:

INTERNATIONAL RADIO Co. Ltd.

438 Queen Street :: Auckland, N.Z.

Phone 31-858 C.P.O. Box 1048

"Founders of the Insulated Wire and Cable Industry in New Zealand"